THE ENGINEER.

Some Modern Gas Engines.

SOME MODERN GAS ENGINES.

In selecting the gas engine for the subject of the present Supplement we have been influenced by the fact that although the progress of the internal combustion motor has been steady and persistent since 1876, when Herr Otto applied the cycle of Beau de Rochas practically, yet during the last year or two it has claimed more than ordinary attention. To the remarkable and rapid success of the suction gas producer much of this popularity is to be ascribed; but the commencement of the construction of very large engines by British firms, and the frequent discussions on the application of gas power to the propulsion of ships and the generation of electricity, have also to be taken into account.

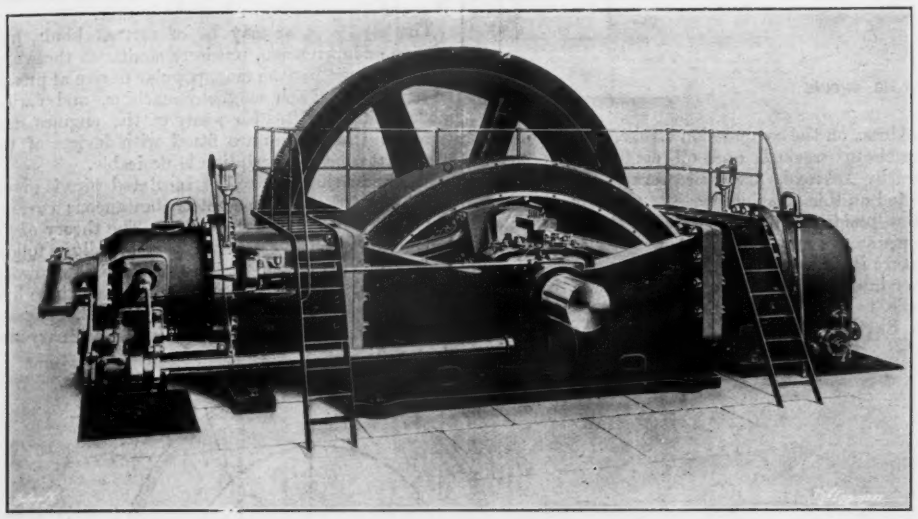


Fig. 1—500 HORSE-POWER TWO-CYLINDER CROSSLEY ENGINE

In the pages which follow we have had to restrict ourselves to the description of engines manufactured in Great Britain. Had we introduced engines of continental and foreign make, a volume, instead of a few pages, would have been required. We have also been obliged to omit all mention of oil engines, a subject with which we hope to deal on another occasion, and which solicits attention at the present time, because it is pitted against a new rival in the suction producer. How it will come out of the contest remains to be seen; its future in the field of agricultural uses will be largely influenced by the trials of engines and producers which are being held in Glasgow, by the Highland and Agricultural Society of Scotland. Of one thing there can be little doubt: it is the remarkable cheapness of power developed by the suction producer and gas engine. The factors in favour of the oil engine are that it can be made more portable than any gas engines and producers that have yet been put on the market, and that it can be started more quickly than its competitors.

When we turn from engines of limited power to those of large size, we are struck by a noteworthy fact. It is that the pioneer work is being done very largely by firms originally devoted to steam engine building, and that, with very few exceptions, the gas engine builders are unwilling to launch out into the costly and anxious experiments which the exploration of unknown fields involves. And within their own lights they are perfectly correct. Their works are as full as they can hold of engines of standard types of moderate size, say up to 500 horse-power, and they can afford to watch the progress of larger engines until such time as there seems a sufficient demand to make it worth their while to take up the construction of them. The introduction of foreign designs—the Koerting and the Cockerill, for example, which the British gas engine builders roundly assert to be without any special distinctive advantages over their own types—is ascribable to the reluctance of the present gas engine builders to give away the experience which they have slowly accumulated, as they would have had to do had they licensed other makers to work under their patents.

The position is possibly correct from a commercial point of view; yet we cannot but feel a species of regret that England should not be in the van of all advances in mechanical engineering, and we rejoice that such an old firm as Crossleys, for example, has entered upon the building of the large engine—the tandem two-cylinder double-acting type—which seems at present to suit the requirements of the ironmaster who wishes to consume his blast furnace gas to the best advantage.

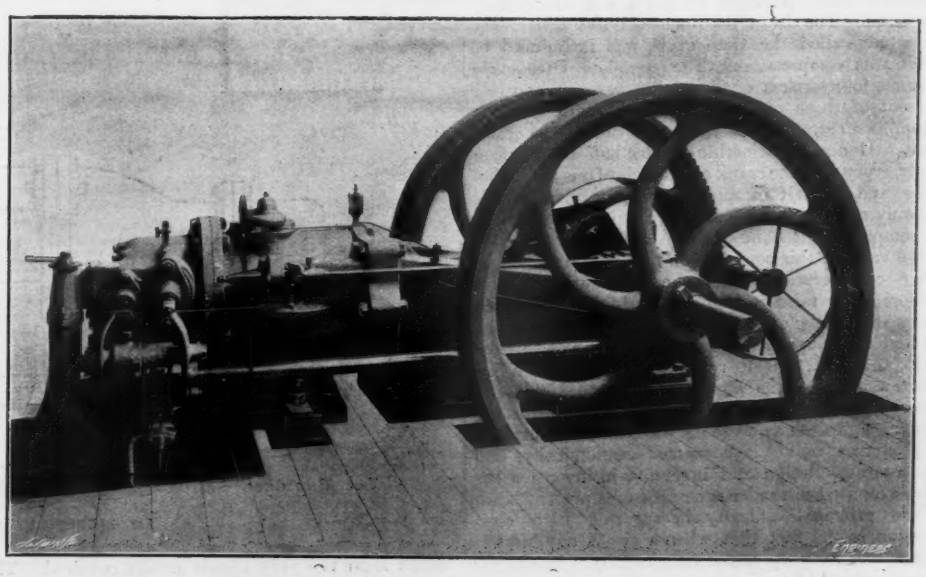


Fig. 2—150 HORSE-POWER CROSSLEY ENGINE

Another direction in which the gas engine makers are practically following a lead given them by steam engine builders is the development of the vertical engine. Without exception they see its disadvantages; but they see also that a demand for it is springing up, and they are all making an effort to find a solution of the difficulties and meet the requirements of the market. To the engineer who is not practically acquainted with the use and manufacture of gas engines, it may look the easiest thing in the world to turn a horizontal engine up on end, and make a vertical of it. Unfortunately, it is far from being as simple as it looks, and it may be worth while to touch quite briefly the prominent features of the problem. Some of these are purely mechanical; others involve difficulties of another kind. Of the first, the arrangement of the valve gear is perhaps the most important. For one reason and another, which could not be explained without entering at some length into the details of design, it has been found impossible to build vertical engines with such simple gear as that of horizontal engines. In a sense, no doubt, the design creates its own difficulties. It is generally intended for the direct driving of electric generators, and it has therefore to run at a high rotational speed; and to secure an even turning movement it has at least three cylinders. Cams and motions which give no trouble at 150 revolutions may be quite unsuitable for three to four times that speed, and the change means increased complexity. Furthermore, a lay shaft, rocking levers, and so on, have to be provided to bring the valves to their correct positions. These little things all mount up, one complication leads to another, and, generally speaking, for engines of the same power the three-cylinder high-speed vertical engine is more complicated than the single-cylinder horizontal slow speed engine.

Another trouble is the position of the piston. A steam engine piston may go year in and year out without examination. Not so a gas engine piston, which should be inspected when possible at intervals of a few months. Now it is quite one thing to remove the piston from a horizontal engine, and quite another to get it into the crank chamber and out through the doors of a vertical engine. The piston is long and fairly heavy, the doors are small, the shaft is in the way, the whole thing is unhandy to get at, and the removal is a troublesome, if not a dangerous, undertaking. The steam engineer may suggest removing the cylinder cover and taking the piston out upwards. Let him examine the design and see the difficulties. All sorts of gearing frequently goes on top of the cylinder, in order to bring the valves, and so on, into the most convenient or best position, or, in any case, the covers are water cooled, and a number of water joints have to be broken, to say nothing of the main joint itself. Altogether, removing the piston of a high-speed steam engine is child's play to getting it out of a vertical gas engine.

Of the second kind of troubles we have mentioned lubrication is one. If the splash system is adopted there is no lack of oil on the piston; indeed, there is a likelihood of too much getting on to it, and being carried into the cylinder, where it may give no little trouble. The correct lubrication of a gas engine cylinder is a very important matter: there should be neither too much nor too little oil; but if anything, an excess is likely to give more trouble than a dearth. We have only to look at the careful contrivances which gas engine builders use to lubricate their cylinders to appreciate this fact.

Finally, the position of the piston courts the accumulation of deposit, which is washed up to the walls by the oil, and may cause all sorts of troubles. In the horizontal engine, any dust or deposit from the charge, or any carbon from the oil, falls to the bottom, and is blown out through the exhaust, which always occupies a low position. In the vertical engine this is not possible. Everything falls upon the piston, which therefore requires more frequent examination than a horizontal piston if excessive friction, inefficiency, or actual jamming is to be avoided.

We seem to have drawn up a very formidable indictment against the vertical engine; but, as these pages show, the problem is being met perseveringly by gas engine builders, and the difficulties have already been overcome in many cases.

Since this Supplement is written partly with the hope that it may find its way into the hands of persons who have not so far much acquaintance with the construction and action of gas engines, it may be desirable, before passing on to the description of some typical designs, to glance at one or two general facts about internal combustion engines.

It was, early in the history of such engines, found that if the explosive mixture of air and gas was compressed before ignition, the power that could be obtained from an engine of given size was greatly increased. The Beau de Rochas, or, as it is more commonly called, the Otto cycle, was introduced to effect this compression. The complete Otto cycle requires four strokes of the engine, two out and two in; out of these only one is active, whilst one, the compression stroke, opposes the rotation of the crank shaft. Hence, for something under half a revolution out of every two the crank and fly-wheel receive an impulse, and for half of another revolution rotation is not only not assisted, but actually opposed, by the act of compressing the new charge. However, so great is the value of this compression that it overweighs all other considerations, and the continual effort of makers is to raise it higher and higher, for with every step in the upward scale the efficiency mounts. At first the compression pressure did not exceed from 20 lb. to 30 lb., but it rose to double that in a few years, and is now as high as 120 lb. to 150 lb. per square inch. With pressures much less than this, the poorer gases, such as those drawn from blast furnaces or producers, cannot be consumed economically, and much care in design and ingenuity in invention has been exercised to render such pressures practicable.

The principal difficulty in securing high compression is the fact that when a gas of any kind is compressed its temperature rises rapidly. If the gas is a compound of an inflammable vapour with a suitable quantity of air, the temperature produced by compression may be high enough to cause spontaneous ignition and explosion of the charge at the wrong moment. Such an action must by all means be avoided. It is prevented largely by cooling the cylinder, and in large engines the piston as well, with a supply of cold water. If this were not done, apart from other effects, the charge would be raised to such a temperature by contact with the hot walls and cylinder that very moderate compression would raise it the small remaining distance to effect ignition. Care has to be taken also that there are no small projections anywhere in contact with the explosive mixture. Every projecting corner must be rounded off, and every part must be kept in contact with the walls or body of the cylinder or piston, so that the heat which it receives during the burning of the gases may be led away before compression begins. A small projection like the sharp corner of a nut, or a particle of carbon, may be sufficient to cause premature ignition by being heated to redness on the compression stroke, and gas engines have been worked, and oil engines such as the Hornsby-Ackroyd, are still worked, with ignition effected on this principle.

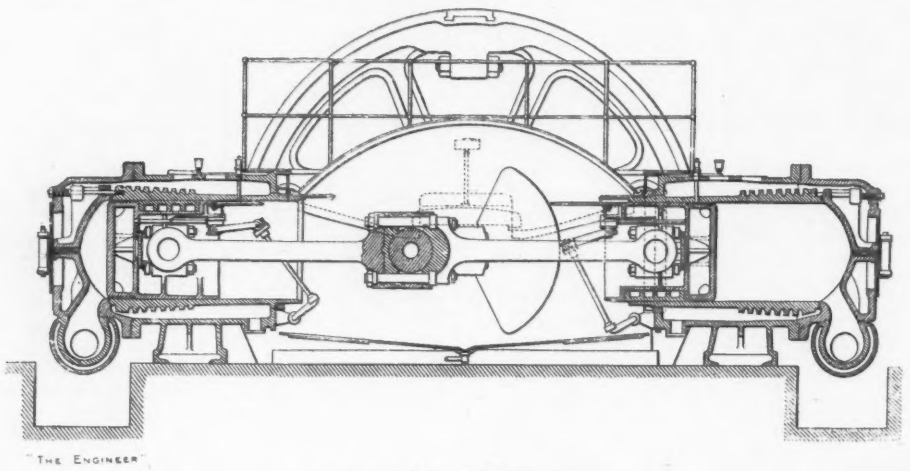


Fig. 3—CROSSLEY VIS-A-VIS ENGINE

But besides cooling the walls of the cylinder and the piston, we may go further, and cool the explosive mixture itself by injecting cold air or a spray of cold water into it. The latter method is used by several people, notably Crossley Brothers and the Campbell Gas Engine Company, who have obtained excellent results from the very simple means required. The former is being tried in some engines of 500 horse-power made by the National Gas Engine Company under Mr. Dugald Clerk's patents. Mr. Clerk's system is to compress air to a few pounds pressure in front of the outgoing piston, and when the cylinder is full of the explosive mixture at atmospheric pressure to turn this compressed air into it. The air has the dual effect of cooling the charge and of raising its pressure by a few pounds, or, in other words, of increasing the density and weight of the charge before compression begins. Mr. Clerk also has obtained excellent results, and an interesting duel will take place between his method and the water-injection method.

The explosive charge having been drawn into the cylinder by an outgoing stroke of the piston and compressed by the next ingoing stroke has, at the moment the crank is passing the inner dead centre or thereabouts, to be ignited. For many years the accepted method of effecting this was to fit a small iron tube, closed at one end and heated externally by a lamp, into the breech of the cylinder. As the piston came back it compressed some of the charge into this tube, the heat of which was sufficient to fire the gas, already somewhat heated by compression. This simple method did well enough on small engines, but the uncertainty of the precise instant of explosion, and the discovery that there was a best particular instant at which to ignite gases of different qualities, and so on, pointed to the necessity of using more precise means.

In the next step of progress the hot tube was still retained, but a timing valve, which excluded the mixture from entering it till a particular position of the crank was reached, was introduced. This combination is still very largely used, but electric ignition is, for many purposes, displacing it. The latter method is employed in engines using poor gas, which will not burn well in the burner required to keep the tube hot, and, of necessity, in all engines fed by suction producers, since there is frequently no supply of gas under pressure to feed the burner.

The electric gear may be of various kinds, high tension or low tension, precisely similar to those used in motor cars; but the most popular device at present is the Simms-Bosch magneto machine, and various modifications of it. So many of the engines mentioned in these pages are fitted with devices of this kind that a brief description is desirable.

We know that if a coil of insulated wire is moved rapidly in front of a magnet instantaneous currents of electricity are generated in it. The theory of the production of these currents is very broadly as follows From the N. pole magnet lines of force flow towards the S. pole, and the action of disturbing these lines of force, by rapid movement of the coil, generates electric currents in the latter. In the ordinary magneto machines which are sold for the use of physicians two coils are rotated in front of a fixed horseshoe magnet. There are various disadvantages in this method which are removed by the Bosch system. In it a permanent horseshoe magnet is used. Between its poles is placed a soft iron armature wound with insulated wire. The lines of magnetic force flowing between the two poles of the permanent magnet pass through the coil and its iron centre. Now, if we turned the armature suddenly through a quarter revolution, its iron core would stand between the poles, and few lines of force would pass through the wire. We should have an elementary alternating generator.

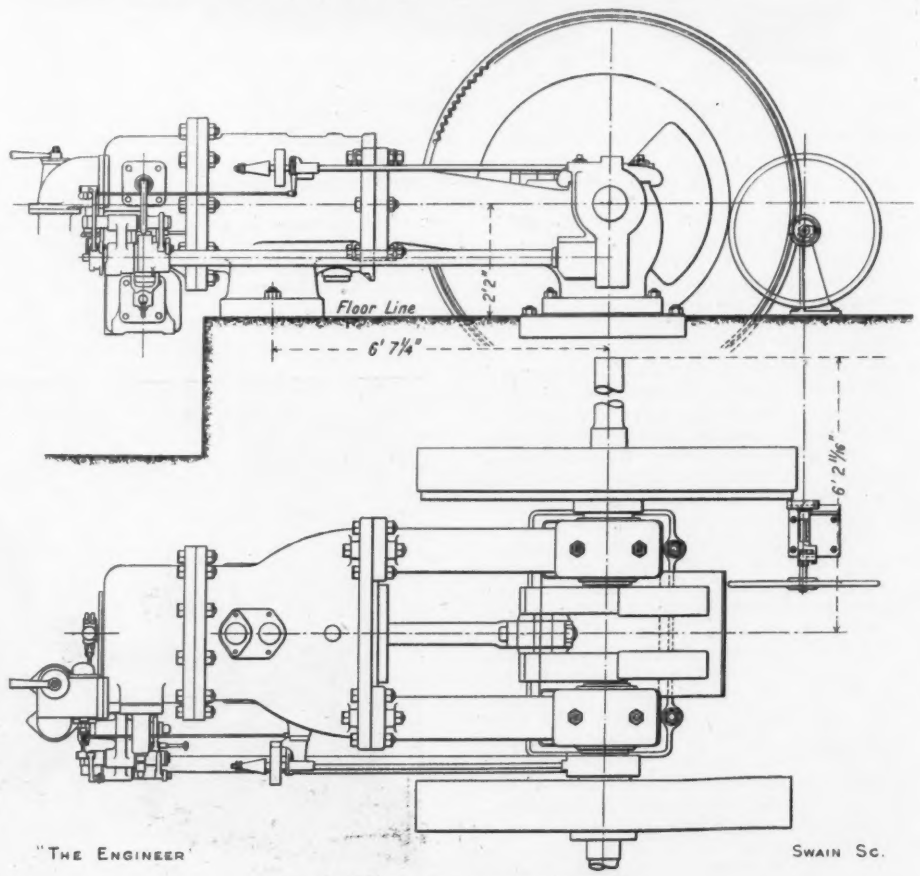


Fig. 4—CROSSLEY SINGLE-CYLINDER ENGINE

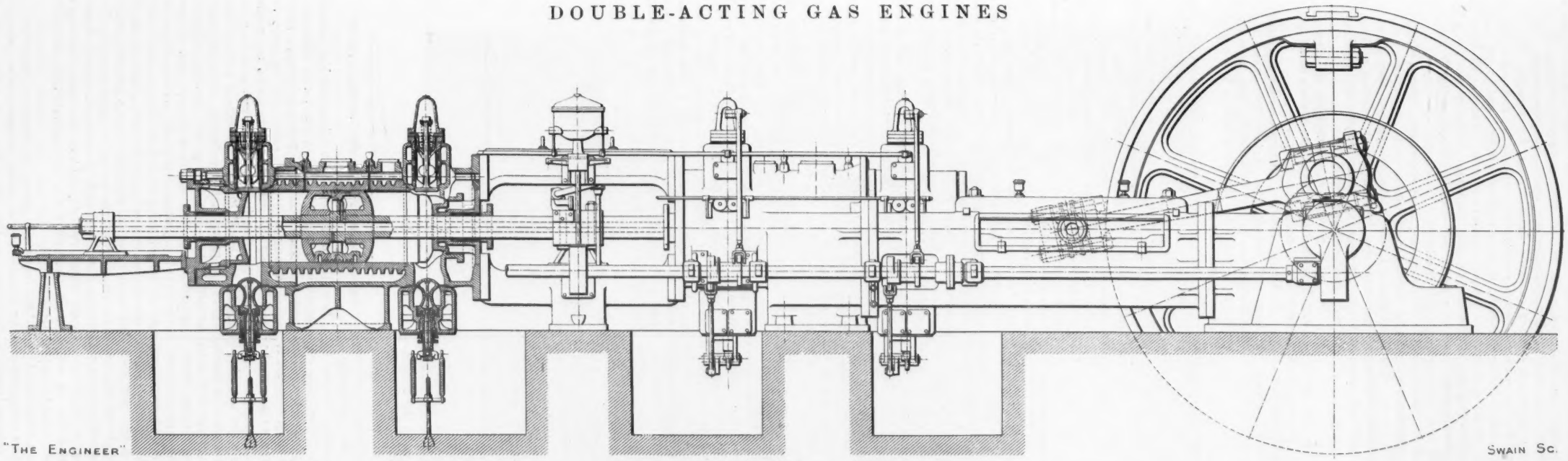


Fig. 5—CROSSLEY'S TWO-CYLINDER DOUBLE-ACTING ENGINE

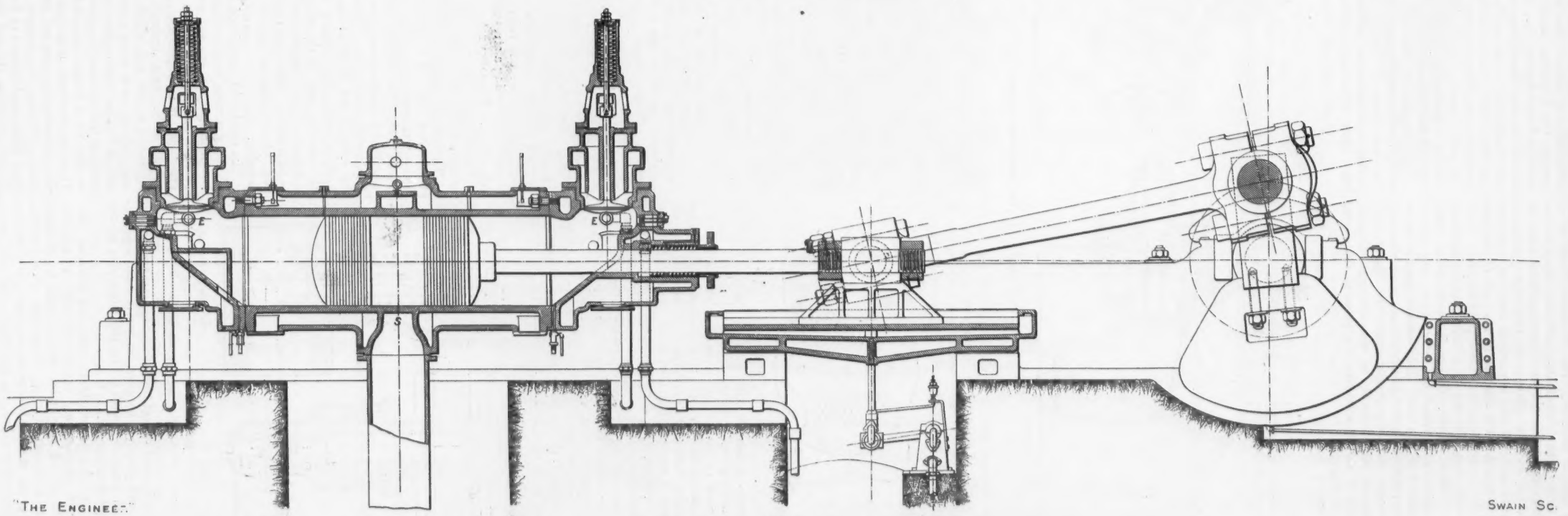


Fig. 6—MATHER AND PLATT'S KOERTING ENGINE

But instead of moving the armature, Bosch moves the lines of force, alternately allowing them to pass through the coil and then deflecting them round it. This he does by placing between the permanent magnet and the coil a movable shield of soft iron. When this shield is directly in the path of the lines of force it carries most of them past the coil; if it is suddenly removed the lines have free access to the coil. If a sudden change is made from either condition a current of very short duration is generated in the coil. The current caused by the sudden deflection of the lines of force when the shield interrupts them is generally employed. The principle is shown very broadly by the annexed diagram, where N and S represent the poles of the permanent magnet and A B the iron core surrounded by a coil of wire. The shields are shown in the position when they have just deflected all the lines of force which may be regarded as emanating from N

Fig. 8

through A and B to S. If at this very instant an interruption is suddenly made in a wire joining the ends of the coil, a spark occurs. The object of the various devices which are employed is to let the shield fly suddenly to this position, and at the very instant it has attained it to break the circuit inside the cylinder, and so cause the spark which fires the explosive mixture.

The sparking arrangement in the cylinder is simply a little arm on the end of a rod which passes through the cylinder cover, and has a similar arm on the outside. The inner arm makes contact with a fixed projection. If the outer arm is struck it raises the inner arm, and breaks the contact. A spring is

Fig. 9—WATER VALVES

generally used to pull the shield into place suddenly—the more quickly it happens the better—and a projection in connection with it hits the outer arm at the appropriate instant.

It will be obvious from what has preceded that with a single-acting engine we only get half the power out of a cylinder which could be obtained if an explosion at every out-stroke were possible. The object of many inventions has been the obtaining of this action; but, on the whole, the Otto cycle still holds it own. One example of a two-cycle engine, the Koerting, made by Mather and Platt, will be found further on. It will be seen that to secure the very desirable compression special air and gas pumps have to be employed, and that in order to do away with exhaust valves and secure a thorough sweeping out of the cylinder by the incoming charge, the piston has to be made, in a double-acting engine, as long as the stroke. Hence it will be understood that there is not the enormous gain in the two-cycle engine which might be expected before the mechanical details were examined, and hence the favour which the four-cycle, or Otto engine, still finds. Under certain circumstances, however, the two-cycle engine has other advantages, which we have not space to

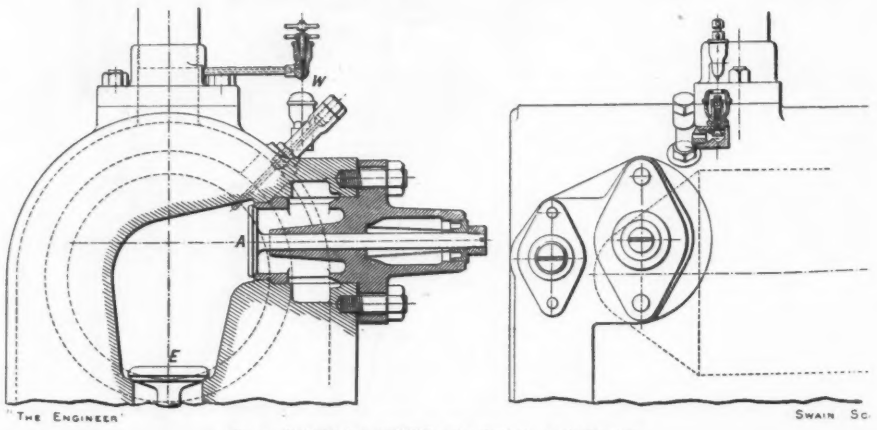


Fig. 7—CROSSLEY WATER INJECTION APPARATUS

discuss, and the Koerting design has proved itself eminently suitable for producer and blast furnace gases.

We may preface the descriptions which follow with a few notes that apply pretty generally to all recent engines working on the Beau de Rochas cycle. Such engines have usually three principal valves, of which two, at any rate, are invariably of the ordinary poppet type; that is to say, they are round discs of cast iron or steel, with bevelled edges, which close a hole in a very obvious way. These two valves are the inlet valve to the cylinder and the exhaust valve. They are worked by cams on a shaft which makes half as many revolutions as the engine, and thus they only open every second revolution, which is a necessary condition of the Otto cycle. Both valves open towards the cylinder, so that the force of explosion or compression tends to keep them closed; but they are hurried on to their seats by springs. The exhaust valve will generally be found at the bottom of the cylinder in horizontal engines, and the admission valve at the top or side. Engines are nowadays always made so that the valves may be removed for examination with the minimum of trouble, generally the simple unscrewing of a few nuts. This is essential, because the efficiency of the engine falls rapidly if the valves allow any gas to pass through them on the compression stroke. In engines of moderate power the valves are quite simple, but in larger sizes many firms consider it advisable to cool the exhaust valve by making it hollow and causing a stream of water to run through the cavity. The temperature of the admission valve, being reduced by the inrush of cold gas and air at every suction stroke, does not require this extra cooling.

These two valves are almost always worked by longish bent levers, and will be easily distinguished, even by those unacquainted with gas engines, in the illustrations. Before leaving the exhaust valve, we may mention that a supplementary cam for use when starting is generally fitted to it. The engine has to be started by turning the fly-wheel against the compression, and by leaving the exhaust valve open for part of this stroke, part of the charge is driven into the exhaust, and, the compression being reduced, starting is facilitated. Once the engine is away, this cam is slid out of action, and the ordinary cam takes up the running.

The third valve mentioned is one under the charge of the governor, and its whole business is to decide how much gas, or gas and air, the engine is to have at each suction stroke. It takes various forms; sometimes it is a piston, sometimes a poppet, sometimes a slide. It is generally closed by a spring and opened by a push rod, which simply goes backwards and forward with every rotation of the cam shaft, and at full load fully opens the gas valve at the same moment that the cam is opening the admission valve, so that gas is drawn straight through to the cylinder. There is, however, a movable connection of some form between the push rod and the end of the valve stem. We may, for example, have a small block of steel which can be raised or lowered by the governor; if it is in place, the rod thrusts against it, and it thrusts against the valve spindle; if it is raised out of place the rod thrusts against nothing, the valve is not opened, and the engine gets no gas. Clearly by suitable modifications, by making the block wedge-shaped, for example, we can cause the gas valve to be opened more or less, and so get a richer or poorer charge into our cylinder. To effect this movement the pendulum governor was for a long time used, but the centrifugal governor has very largely displaced it.

In concluding these elementary notes—with which we must ask the patience of those who are fully acquainted with these things—we may direct our readers to the drawing and description of Tangye's engine on page ix., where the principal parts may be very readily distinguished.

We must now leave generalities, and describe a few of the leading types of gas engines as at present made in this country.

To Messrs. Crossley Brothers is due the introduction and development of the Otto cycle, and in consideration of the effect it has had upon the gas engine industry we deal first with a few engines of their make.

The single-cylinder engine, illustrated by Figs. 2 and 4, is their usual type for engines of from 90 to 150 horse-power. It will be seen that the framing of the engine mainly consists of a substantial water-jacket casting securely attached to two side frames carrying the main bearings, these two side frames being further secured to each other by a sole-plate extending under the main bearings. This arrangement of framing, which has been arrived at as the result of many years' experience, has proved to be very satisfactory. The engine rests, it will be observed, practically upon three points, viz, under the two bearings and the cylinder, so that any slight settlement of foundation is less liable to put it out of line. As it can be taken apart into relatively small pieces it is possible to get an engine into confined spaces; and where facilities for lifting heavy parts are not available these separate parts are also more easily handled.

The breech end is a separate casting, and as it is usually considered to be the most vulnerable part of a gas engine it is made a comparatively small piece to renew in case of damage. Within the last few years, however, Messrs. Crossley Brothers have adopted a special form of breech end which, they inform us, has proved itself to be thoroughly trustworthy. In this arrangement the inner metal is kept free from the outer metal in the casting, excepting at two points more or less at right angles to each other, a number of screwed stays subsequently being inserted to join the inner metal to the outer metal, so as thoroughly to combine the two for their mutual support. The outer end of the breech end casting has a large circular opening in it covered by a thin plate, the object being to prevent straining, through variations in temperature whilst at work, and to provide thorough facilities for cleaning.

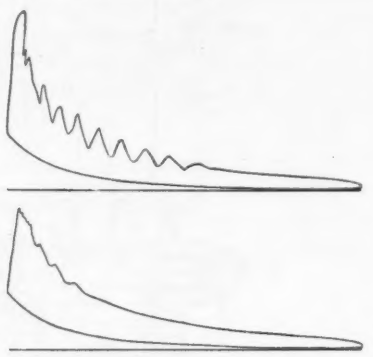


Fig. 10—DIAGRAMS WITH AND WITHOUT WATER

It will be noticed that the valves and their gear are compactly arranged, and that the valves themselves are readily removable for cleaning purposes. Lubricating arrangements for every moving part are provided, and can be attended to whilst the engine is running. We have notes of instances in which engines of this make run throughout a whole week without stopping, and occasionally for much longer periods. The main bearings are provided with ring lubrication, which keeps them flooded with oil used over and over again, and provision is made to prevent any of this oil being wasted or thrown about. For turning the engine by hand a rack is cast on the fly-wheel, suitable barring gear being provided, which can be thrown into or out of gear at will. This barring gear is operated by means of a smooth-rimmed hand wheel, so that if from any cause the engine should start when it is being operated the attendant is not injured.

One important recent improvement in details of the Crossley engine is the exhaust valve, which is illustrated in Fig. 11. The casing is a separate

casting bolted to the underside of the breech end with a spigot and faucet joint, whilst the valve itself is a hollow casting carried in a small removable cylinder. The portion of the valve fitted to this cylinder is rather smaller in area than the valve proper, which is thus partly balanced, the force required to raise it being greatly decreased. A suitable spring is enclosed in this small removable cylinder to keep the valve on its seat. It will be seen that the valve itself is thoroughly well guided, and that it and the valve casing are water-jacketed; as the hot exhaust passes away out of the other end of the casing the sliding parts remain cool, and can be thoroughly lubricated. As the bottom of the valve is about the same level as the floor of the engine-house, it is slid out or in without difficulty.

Recent electric developments demand a gas engine which will run with sufficient steadiness to drive alternating dynamos in parallel. This may be done, in some instances, both with engines having one single-acting cylinder or two single-acting cylinders fitted with very heavy fly-wheels. If, however, a gas engine is made which will give two working strokes per revolution, extremely close rotative steadiness can be assured. This can be obtained by suitably combining four single-acting cylinders working on the Otto or four-stroke cycle, or by having two double-acting cylinders as shown in Fig. 5 on page iii.

In this engine the crank shaft is fitted into a very substantial frame, to which are bolted side frames, carrying guiding surfaces, for the small end of the connecting-rod. The cylinders are bolted to each other and to these side frames, so that all end stresses are directly transmitted to the main frame. The main casting of each cylinder forming the water jacket is the part which is attached to the side frames, and provision is made in these jacket castings for the valves for one end. The valves for the other end are arranged in a separate casting, which is free end-wise in relation to the main casting. The liner forming the working surface of the cylinder is a plain cylindrical casting, and thus can be made of hard, close-grained metal, being held between the fixed portion of the water-jacket and the free portion by long bolts passing through from one end to the other. Suitable covers are arranged for the removal of the pistons and piston-rods; and arrangements are made for watering the pistons and piston-rods. A powerful governor controls the gas in such a manner as to regulate the power given out by each impulse, unless the engine is running on a very light load, when some of the impulses may be entirely cut out.

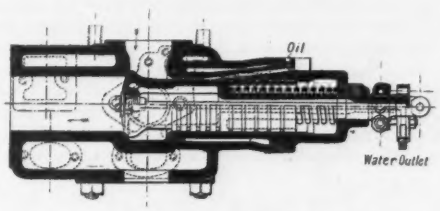


Fig. 11—CROSSLEY EXHAUST VALVE

An account of modern gas engines without mention of the *vis-à-vis* engines, Fig. 1, made by this firm would be very incomplete. We give a section of it, Fig. 3, taken from Mr. Clerk's "James Forrest" lecture, and we are tempted in this connection to quote a very true observation from that lecture. "It must never be forgotten," said Mr. Clerk, "that the engineer frequently abandons the path of theoretical rectitude in order to obtain success in the practical operation of his mechanism." We may modify this slightly without altering its truth. In place of the last few words, let us say "to obtain success in the market," and we have a very exact observation about the famous *vis-à-vis* engine. Every engineer, and certainly Messrs. Crossley Bros., no less than others, recognise its defects—the unbalanced reciprocating forces are almost at a maximum in an engine of the kind—and yet it is simple, it is cheap to make, it runs well, and, above all, it sells well. Therefore the makers desert the path of "theoretical rectitude" and make it, and very wisely too.

We have already mentioned the fact that this firm has fitted several gas engines with a device for injecting water and allowing of increased compression. The matter is of such importance that we quote some abstracts from a report by Professor Burstall on the test of an engine of this kind developing about 50 brake horse-power. The trial lasted six hours and three-quarters, and may therefore be considered a fair running test. The average horse-power was 60·5; the average brake horse-power, 49·7; the mechanical efficiency, 82·2 per cent. The calorific value of the gas was 578 B.T.U. per cubic foot. Of it 11·77 cubic feet were used per indicated horse-power and 14·43 per brake horse-power per hour. The thermal efficiency on the indicated power was 37·43, which, Professor Burstall remarks, "is the highest thermal efficiency which has to my knowledge been obtained in any test." The thermal efficiency on the brake-power was 30·8 per cent. These remarkable figures show that water injection is a promising method of improving the gas engine. The apparatus employed is shown in Figs. 7 and 9.

The introduction of a little water to the cylinders of gas engines is by no means a novelty, but to effect it successfully has proved to be not an easy problem to solve. It is necessary to success to spray the water very minutely, and to introduce it practically uniformly mixed up with the whole bulk of the incoming charge. After numerous experiments, the arrangement shown has been adopted by Crossley Brothers. It will be seen that a small, self-acting valve, very lightly spring loaded, is inserted in the bottom of a cup, which receives a regulated supply of water flowing into it constantly. When the suction stroke commences, this water, together with a considerable amount of air, is drawn into the cylinder, the air dispersing the water into fine spray, and delivering it on to the top of the entering rush of the main body of the charge. By this novel way of introducing it the water never reaches the sides of the cylinder to any appreciable extent, and, moreover, it enters as water and not as steam, a very important factor, from a thermo-dynamical point of view, inasmuch as it thus beneficially reduces the temperature of the charge during admission and also during compression. It must be understood that if water, to any appreciable extent, reach the surfaces of the cylinder, it interferes seriously with the lubrication, the oil and water combining to form a brown, pasty mass, which causes the piston rings to stick, and may

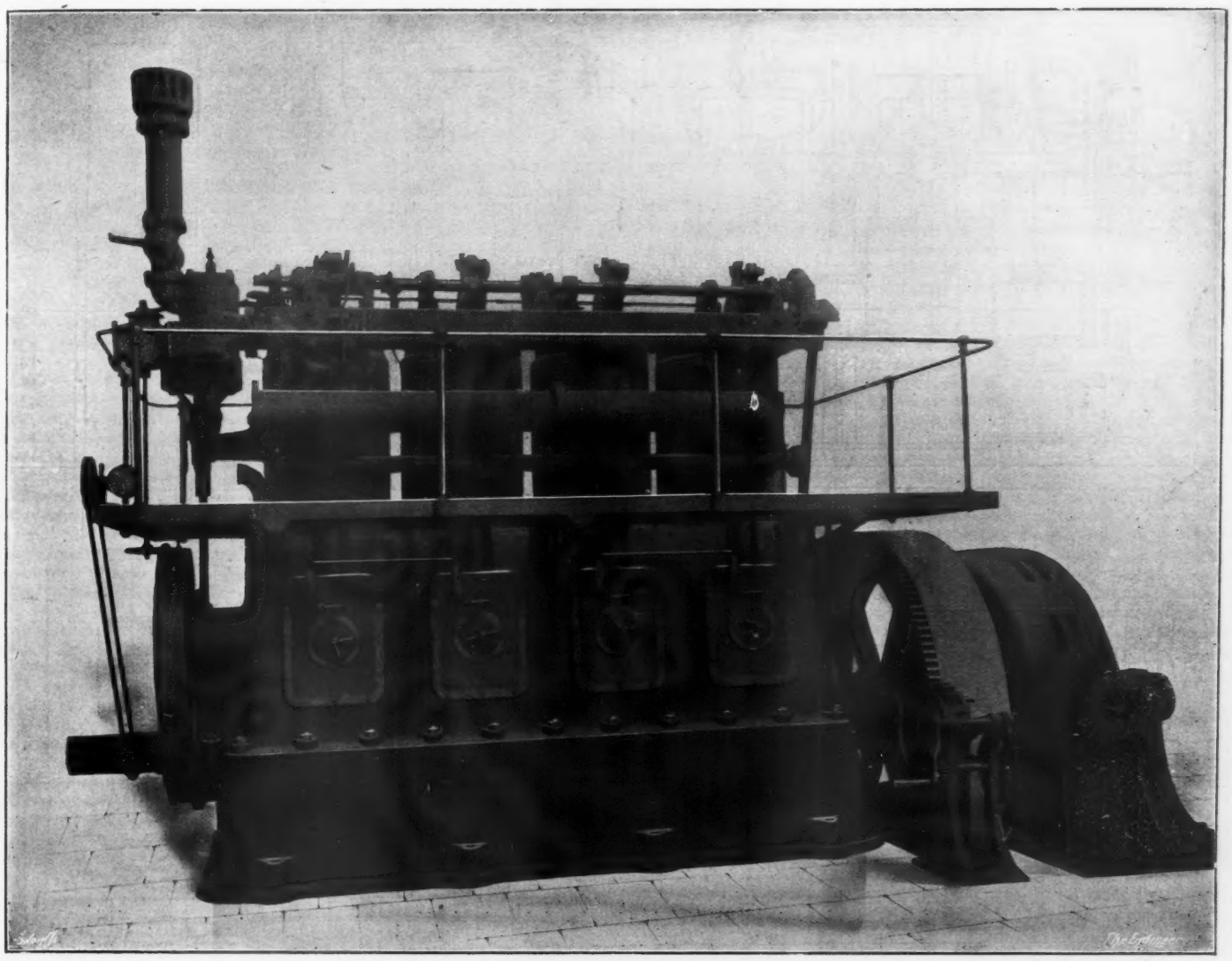
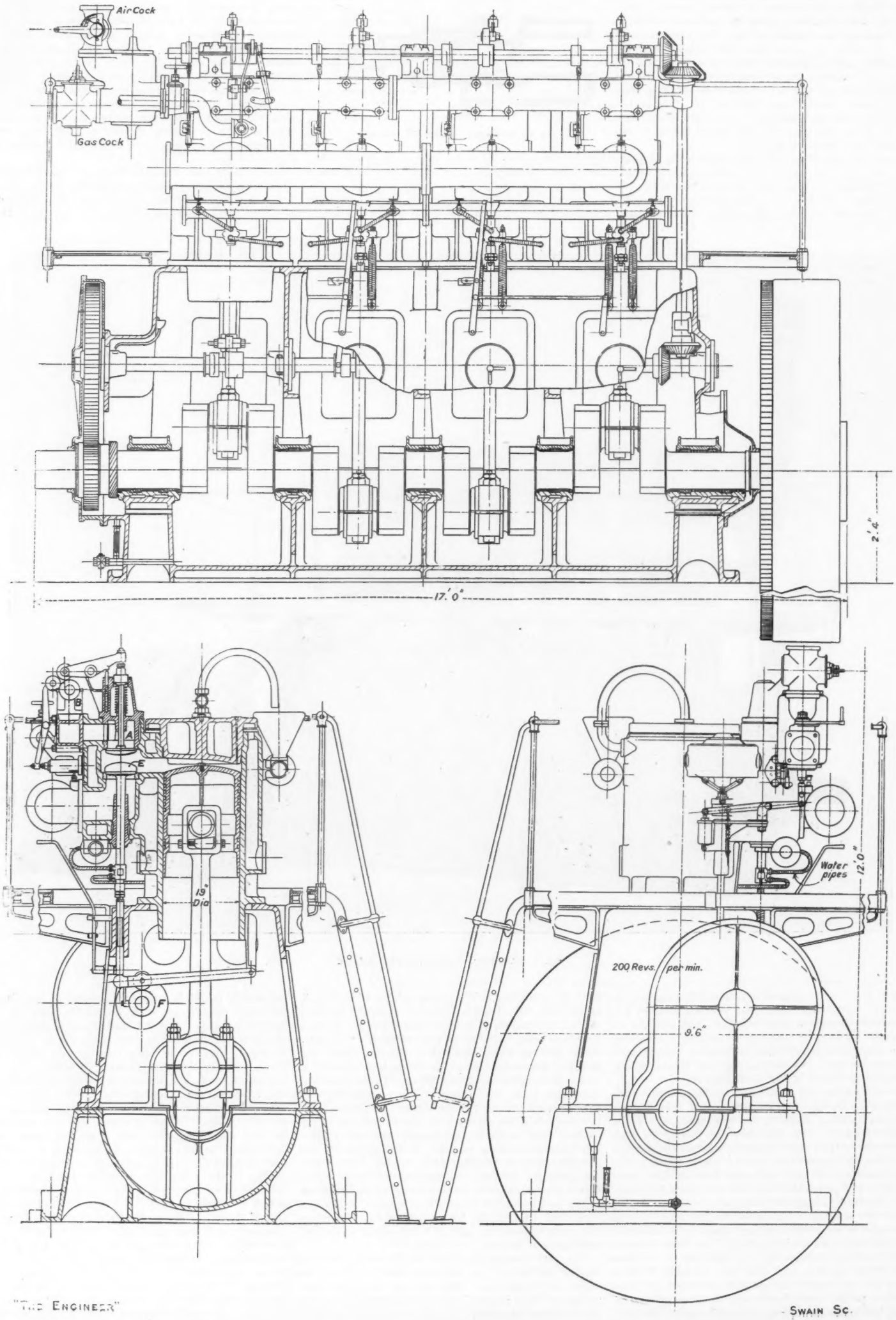


Fig. 12—CAMPBELL FOUR-CYLINDER ENGINE

FOUR-CYLINDER VERTICAL GAS ENGINE

THE CAMPBELL GAS ENGINE COMPANY, LIMITED, HALIFAX, ENGINEERS



"THE ENGINEER" SWAIN Sc.

bring about leakage and possibly serious wear of the liner. It has been found that several times the desired quantity of water can be admitted in the manner described without interfering with the lubrication.

The effect of the introduced water is shown in the diagrams, Fig. 10, taken from the same engine, with the same load and the same amount of gas per impulse. Without water, upper card, the ignition is very sharp and loud, and the initial pressure is very high; with water the ignition is more gradual, the initial pressure is not so high, and the engine works smoothly, satisfactorily, and is also fully as economical.

The main features of the engine are found in the arrangement of the valve gearing. The cam shaft F for operating the exhaust valve E, is enclosed inside the crank casing, and is driven by machine-cut spur and pinion wheels made of steel. At the opposite end of this shaft is placed a vertical shaft, which, in its turn, drives by means of bevel wheels a horizontal shaft B, on top of the cylinders, to which are keyed the cams for operating the inlet valves A, and ignition gear. Electric ignition is employed, each cylinder being fitted with an independent magneto machine. The contact breakers or sparking plugs are in duplicate, and the change over from one set to the other can be made while the engine is running. The point of ignition can be easily varied while the engine is at work; the exhaust valves are built up, the spindle being of forged steel, while the head is of cast iron, and the whole is water-cooled. The inlet valve for the admission of the air and the gas to each cylinder is fitted in a loose valve box, so arranged that it can be taken out easily for examination.

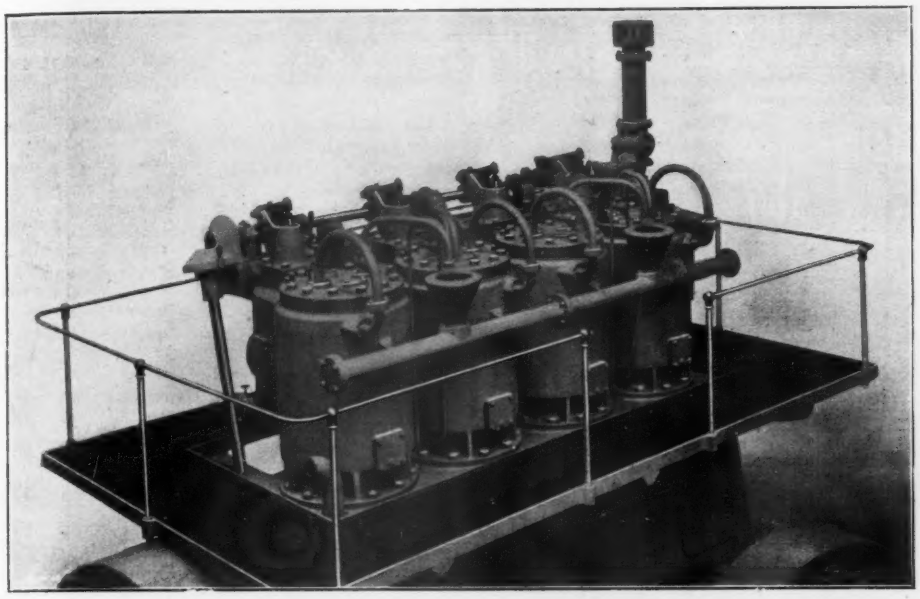


Fig. 13—CYLINDERS OF CAMPBELL VERTICAL ENGINE

With many kinds of gas, the engine, if kept on a full load without water would probably cause trouble from pre-ignition, but with the water any such risk is avoided. To avoid additional holes in the cylinder, the arrangement is made so that the same hole serves for the introduction of the water and for indicating the engine. The amount of water found desirable requires at least 10 per cent. of the total heat in the gas to convert it into vapour—that is to say, the latent heat of the water is 10 per cent., or slightly over the total heat in the gas, and as this water is converted into vapour before the termination of the compression stroke, it will be seen that the temperatures throughout the whole cycle of operations are materially reduced, and a beneficial effect in preventing fractures of cylinder parts due to high temperature stresses is brought about.

We may here appropriately describe another engine using water injection. It has been recently completed by the Campbell Gas Engine Company, Limited, Halifax, for the Bahia Blanca Lighting Station of the South America Light and Power Company,

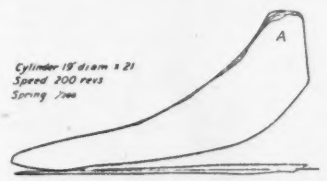


Fig. 14—EFFECT OF WATER INJECTION

Limited, and was tested for one week by Sir Douglas Fox and Partners, the consulting engineers to the purchasers. It was coupled direct to a two-phase alternator of 240-kilowatt capacity, and ran during part of the test, at 10 per cent. overload. The engine is of the vertical four-cylinder enclosed type, illustrated by a drawing on page vi., and two views, Figs. 12 and 13, and its normal output is 360 brake horse-power, at a speed of 200 revolutions per minute. This power is developed when using producer gas having an average heat value of 140 British thermal units. The maximum brake horse-power is 400. It has four cylinders 19in. diameter by 21in. stroke, each cylinder being independent of the others. The crank shaft and bed-plate have been specially designed for hard and constant work. To prevent bending or distress of the shaft five bearings have been fitted to the crank inside the casing, each of the bearings being 9½in. diameter, while their lengths vary with their positions. The bed plate is strongly ribbed underneath, the object being to prevent twisting, either under the load it has to carry or under pressure developed by the engine.

The governing of the engine, upon which so much depends for electric driving, is done by a governor of the "Hartung" type, operating a balanced throttle valve, which controls the volume of combustibles according to the load. The governor itself is driven direct from the crank shaft, and independent of other mechanism connected with the engine. It is sometimes the practice to drive the governor from the cam shaft, but this has been found to be unsatisfactory, as the hammering action of the cams considerably affects the action of the governor.

The system of water injection is the same as that used by the makers in their oil engine, for the last seven or eight years. To illustrate its effect in the cylinder of the engine we reproduce herewith an indicator diagram, Fig. 14, taken from one of the cylinders with a load of 240 kilowatts upon the engine. In the flat "corner" marked A the action of the water is clearly seen to have prevented a rise of pressure and temperature, but in return it has enabled the gases to expand during the remainder of the stroke, as is evident from the "full body" shown in the diagram; so that while the water injection prevents the abnormal development of maximum pressure and temperature, yet a mean pressure is secured which is greater than if the water injection had not been adopted.

The engine built by Mather and Platt, Limited, of Manchester, is designed on lines more suitable for large than small sizes, and is therefore not made to develop less than 300 horse-power. On the other hand, the limits to its power in the opposite direction are wide, as much as 1000 horse power being obtained from a single cylinder. The engine is the Körting, a two-cycle engine with separate pumps for providing the explosive charge. It is, moreover, double-acting,

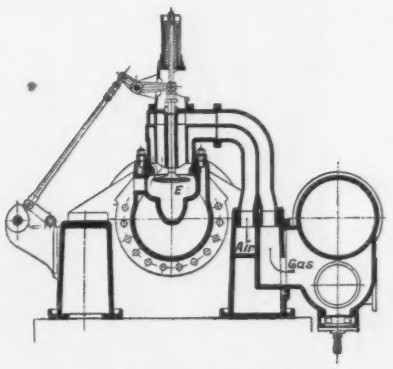


Fig. 16—MATHER AND PLATT ENGINE

the piston being driven both out and in by explosions. Turning to the section on page iii., the action will be readily understood. The admission valves are marked E and E; the exhaust takes place through the passages by holes, which are uncovered by the piston at the end of its stroke. The piston therefore acts as an exhaust valve, and it has, in consequence, to be made very nearly as long as the stroke. At the instant shown the exhaust ports are fully uncovered, and first a charge of pure air from the air pump has entered through E and has blown the products of combustion out through the exhaust. It is followed a little later by a supply of gas from the gas pumps, which, mixing with the air already in the cylinder, forms the explosive charge. On the return stroke of the piston this charge is compressed, and at the appropriate instant, which may be regulated to a nicety, is ignited electrically at two places, so that combustion may be thorough and complete. Precisely the same action occurs at each end of the cylinder alternately.

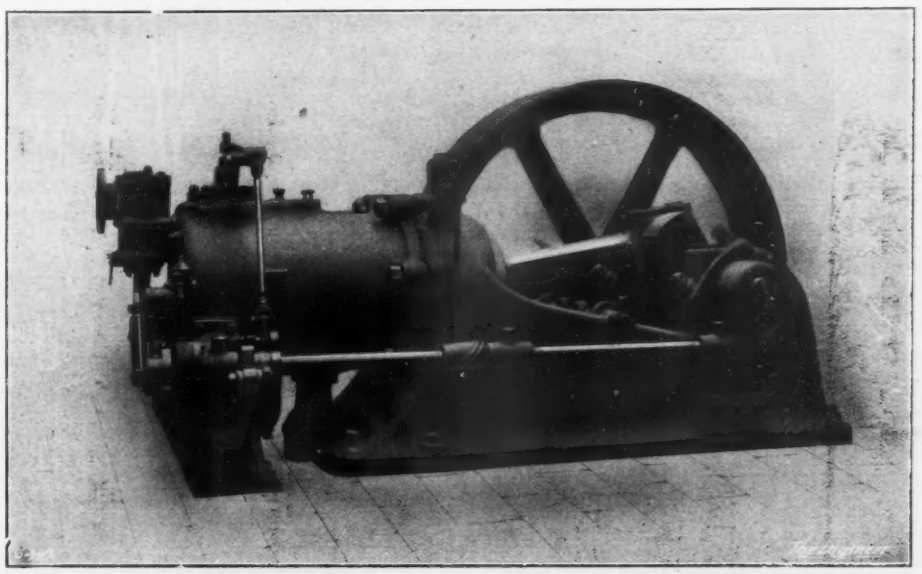
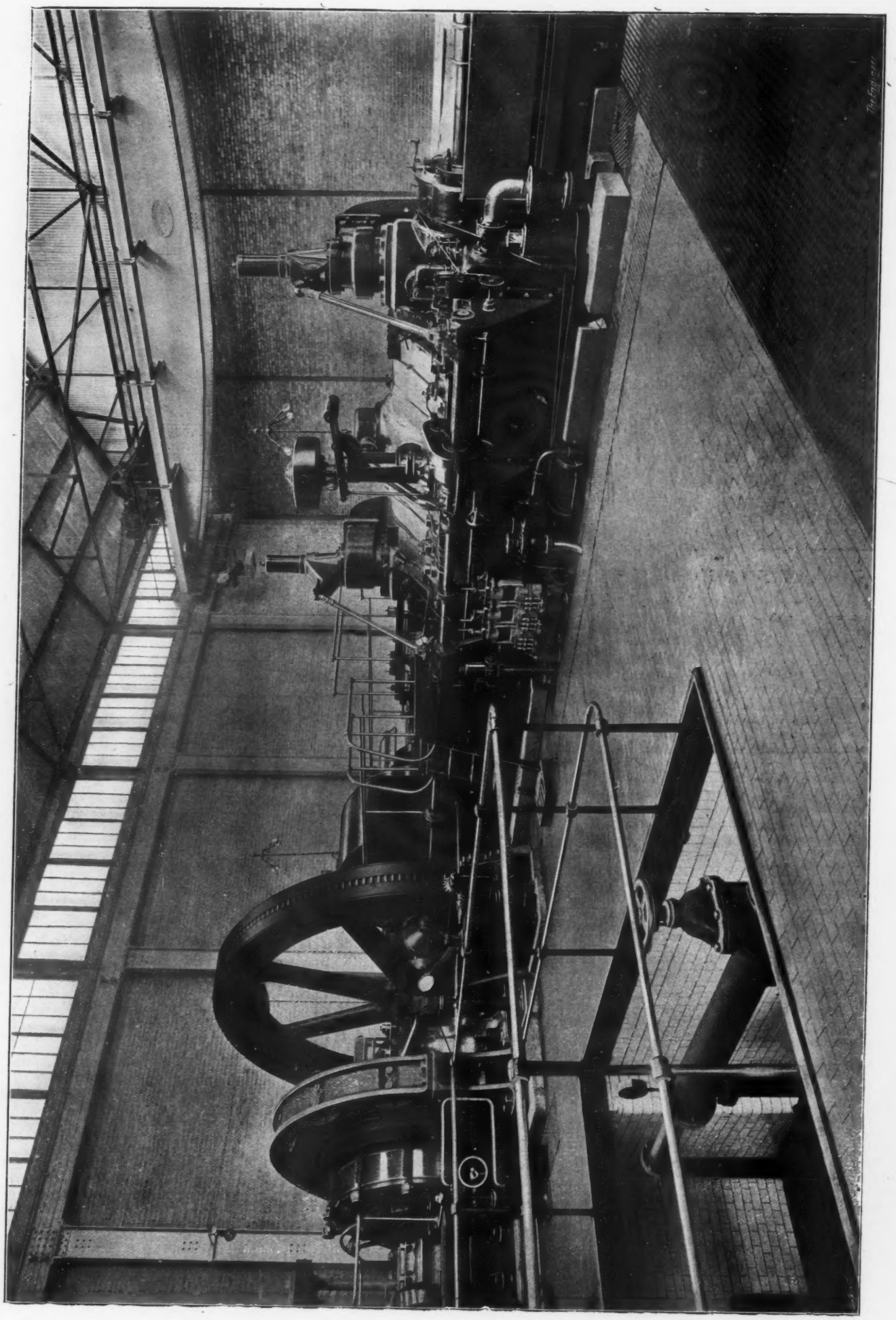


Fig. 15—TANGYE HORIZONTAL ENGINE

The gas and air pumps are placed beside the cylinder, tandem to each other, and are driven by a crank on the main shaft, a connecting-rod, crosshead, slipper guide, &c., being provided. Their delivery valves are operated by an excentric. The position of the admission valves is well shown in the section and the method of operating them is better seen in the small cross-section—Fig. 16—which shows also

700-B H.P. KOERTING ENGINE AND DYNAMO

MATHER AND PLATT, LIMITED, MANCHESTER, ENGINEERS



the position of the gas pump and the duct from the air pump.

Governing is effected by throttling the gas supply, the gas valve remaining open for long or short periods, according to the load. Since the gas always enters after the air, and does not mix immediately with it, the back part of the charge is always rich, no matter how small the supply of gas, and hence ignition is certain. By this means of governing the cyclic regularity of the engine is not interfered with; an explosion takes place at every stroke, however light the load may be, and a constant and regular turning effort is the result, the governor regulating the charge to the precise richness required.

The engine is started by a supply of air compressed by a belt-driven pump to about 120 lb. A starting valve, which can be put in and out of gear by a clutch whilst the engine is running, admits this air to the power cylinder, and the engine gets away at once. When the normal speed is reached, the clutch is thrown out, the air valve is closed, the gas valve opened, and the cylinder commences to draw its own charges, ignite them, and run automatically.

The cooling arrangements are very complete. The cylinder itself is, of course, water-jacketed in the usual way, and so also are the cylinder heads, the metallic packing stuffing-boxes, and the belt surrounding the exhaust ports. Furthermore, water is led to one side of the crosshead, thence through the piston-rod into the piston, back through a pipe in the centre of the rod, and so away by an exit on the other side of the crosshead.

This engine differs so radically from all the others illustrated that it may be well to state the claims made for the design. They are, first, perfect scavenging, obviating any fear of pre-ignition by cooling the cylinder and removing all traces of the hot products of combustion; secondly, the absence of heavy exhaust valves; thirdly, the use of a crosshead and guides, removing the up and down load from the piston and permitting of the pin being kept cool and easily lubricated; fourthly, the smaller cylinder diameter required, because the cycle is two instead of four-stroke; and fifthly, great steadiness of running owing to an impulse being given at every stroke.

A great aggregate horse-power of engines of this kind has been made, most of it being developed from producer or blast-furnace gas. An illustration of one of two handsome engines built on these lines, for use with Mond gas at the Castner-Kellner Alkali Company's works, is given on page viii. The gas has a calorific value of 150 B. Th. U.; the engines are rated at 700 B.H.P., but frequently respond to a call for 750. The cylinders are 73 c.m. (about 29½in.) diameter by 1·3 metres (about 54in.) stroke. The speed is 85 revolutions per minute. The overall length is 14 metres, the breadth 7 metres. The engine drives a dynamo by direct coupling.

A well designed engine is made by Messrs. Tangyes, Limited, Birmingham, and an example, developing 115 effective horse-power with suction gas, is illustrated by Fig. 15. The engine works on the Otto cycle, and being intended for suction gas the ignition is electric. The magneto may be made out at the end of the cylinder. It is fitted with a very pretty and simple gear for timing the ignition. On the end of the cam shaft is a small crank disc, which drives a light connecting rod, supported near its far end by a short upright lever. On the end of the connecting-rod is a hook or catch, which engages with a lever keyed to the shield of the magneto. As the crank revolves the connecting-rod pulls back the magneto shield to a predetermined point, when the short upright lever is vertical. At this point the upright lever has raised the connecting rod until the hook has been lifted clear of the lever with which it engages, and the shield flies back under the influence of a spring. This condition is shown in the annexed diagram, where the vertical rod is X A, fulcrumed at A. Now suppose the fulcrum moved to B, the vertical position will be reached later, and the time of ignition will be retarded. By means of a small wheel and screw the fulcrum can be adjusted to precisely the desired position. Actually the hook rod is inclined; it is marked K in the end view, Fig. 17.

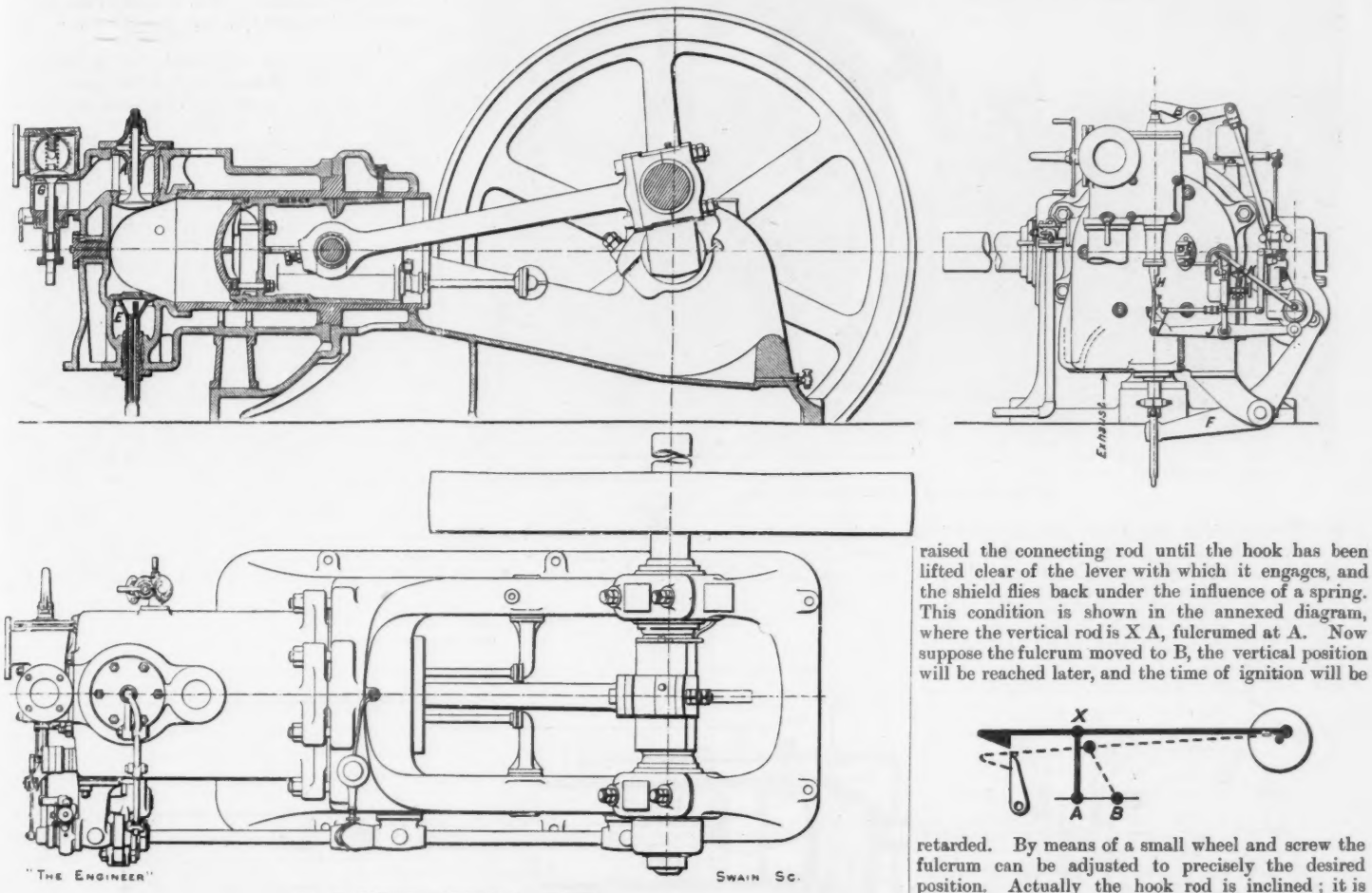


Fig. 17—TANGYE HORIZONTAL ENGINE.

The engine itself is of a very simple character; no difficulty will be found in understanding it from the drawings, Fig. 17. It has a separate liner, the outside casting forming the water jacket, and both the piston and exhaust valve are water-cooled. A centrifugal governor is used, which by means of a connecting-rod and hit-or-miss gear, H J, Fig. 17, worked by the last cam in the shaft, cuts out or admits the gas supply through the valve G. The admission

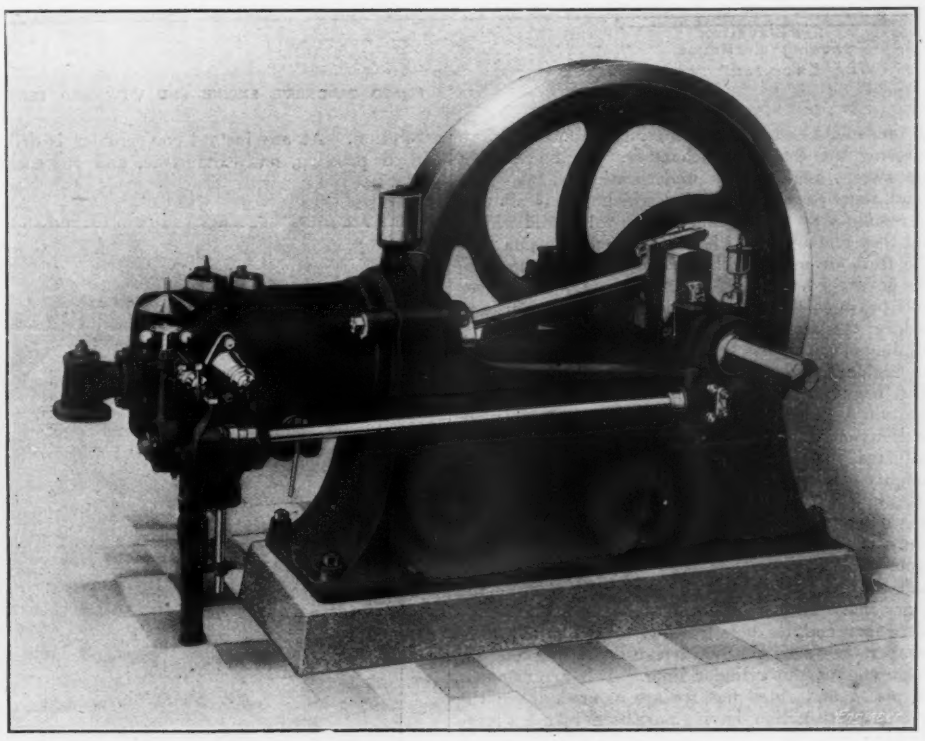


Fig. 18—FIELDING AND PLATT ENGINE

valve A is placed on top of the cylinder, and the exhaust valve E at the bottom.

It will be seen that these valves are so arranged as to dispense with all unnecessary passages, and thus present as little cooling surfaces as possible to the burning gases. The gas and air inlet valve allow of an immediate and complete mixing of the two before entering the combustion chamber. As the entering air sweeps immediately underneath the gas valve head, there are no passages in which gas is allowed to remain after the closing of the valve, and which, did they remain, would be lost through diffusion with the fresh air entering the cylinder during the time the governor has cut off the gas supply. The valves and passages have been made exceptionally large to reduce the friction of the entering gases to a minimum, as this has been found very desirable when an engine is to work with a "suction" gas producer. The compression of the gaseous mixture before ignition reaches as much as 130 lb. per square inch, and arrangements are provided whereby it can be adjusted, when the engines are fixed at various heights above sea level. From the illustration, Fig. 16A, it will be seen that the rings on the piston are carried as forward as possible towards the crosshead pin. This arrangement keeps them as far away from the heat as possible, allows of better lubrication, and so reduces the wear of the cylinder liner at the inner end. The piston has, however, a single ring at the inner end, its object being to act as a kind of scraper, preventing any carbon depositing on the inner end of the cylinder liner. This arrangement of piston and rings has, we are assured, given the greatest satisfaction, having now been in use a large number of years.

Another firm which has successfully attacked the problem of the vertical gas engine is Messrs. Fielding and Platt, of Gloucester. A complete description of their design was given, with sectional drawings, in our issue of August 28th, 1903, and whilst those who wish to study the question fully will refer to that number, we may now briefly touch upon the salient features of the design. The engine has four cylinders in two pairs. There are four cranks, the pins of each pair being at 180 deg. to each other, so that two pistons are right in whilst the other two are out. The Otto cycle is used, and the crank shaft receives two impulses per revolution. At any instant one cylinder is driving, one compressing, one exhausting, and one sucking. A perfectly regular and steady turning moment can only be obtained in this way if the four-stroke cycle is employed. The cylinder liners are all quite independent of each other, except that they are all attached to one base-plate, and that one water jacket is used to each pair. The base of the engine is of the enclosed steam engine pattern, with large circular doors back and front. Oil is contained in the well, and lubricates by splash in the usual way. The admission valve is placed right in the top of the cylinder, the exhaust a little behind it, and the cam shaft lies behind the cylinders just below the exhaust outlets.

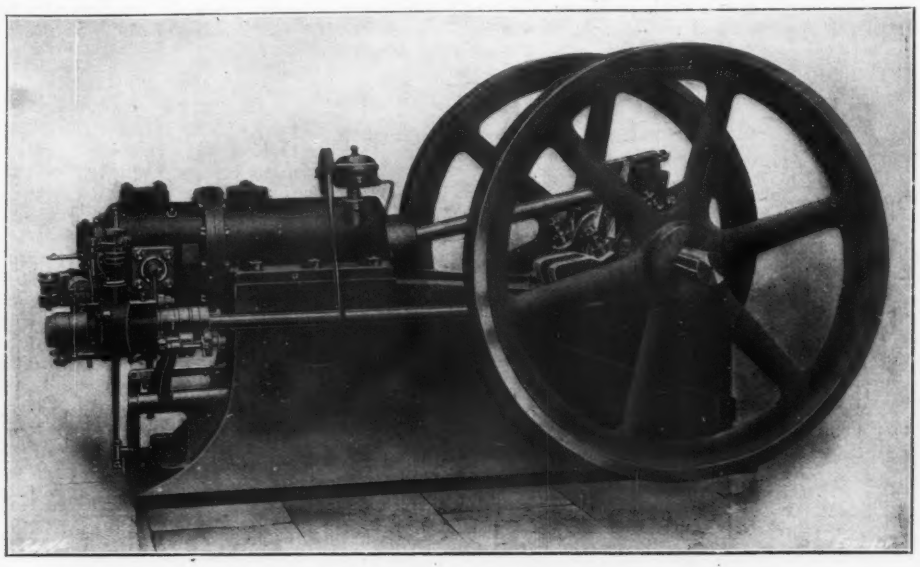


Fig. 19—GARDNER'S HORIZONTAL ENGINE

The engines are controlled by a centrifugal governor of the Hartnell type, which acts upon an ingenious air and gas throttle valve, and also regulates the time of ignition.

Besides this vertical type engine, Fielding and Platt, Limited, make also horizontal engines, one of which, intended especially for driving a dynamo direct, we illustrate, Fig. 18. It is, it will be seen, of the now standard type. The valves are worked off the cam shaft in the usual way; a centrifugal governor, controlling the air and gas supply, is used to regulate the speed, which can be adjusted whilst the engine is at work. The cylinder is built up with a hard steel liner and external water jacket in the usual way.

A larger engine, somewhat on the same lines but working to 300 horse-power, with producer gas, is also made by this firm.

The drawing, Fig. 20, shows an end elevation and a sectional plan of an engine, made by L. Gardner and Co., Ltd., of Patricroft, Manchester. It is of the usual horizontal type—see Fig. 19—with side shaft, working on the Beau de Rochas or Otto cycle. The construction of the cylinder will be seen from the drawing. The combustion chamber, with its water jacket and the seatings and ports for the gas, inlet, and exhaust valves, form one casting. The front portion of the water jacket, which encloses the cylinder proper or liner, is a separate casting, to which the combustion chamber is bolted. The liner is held in position in the usual manner by T-headed bolts, the latter

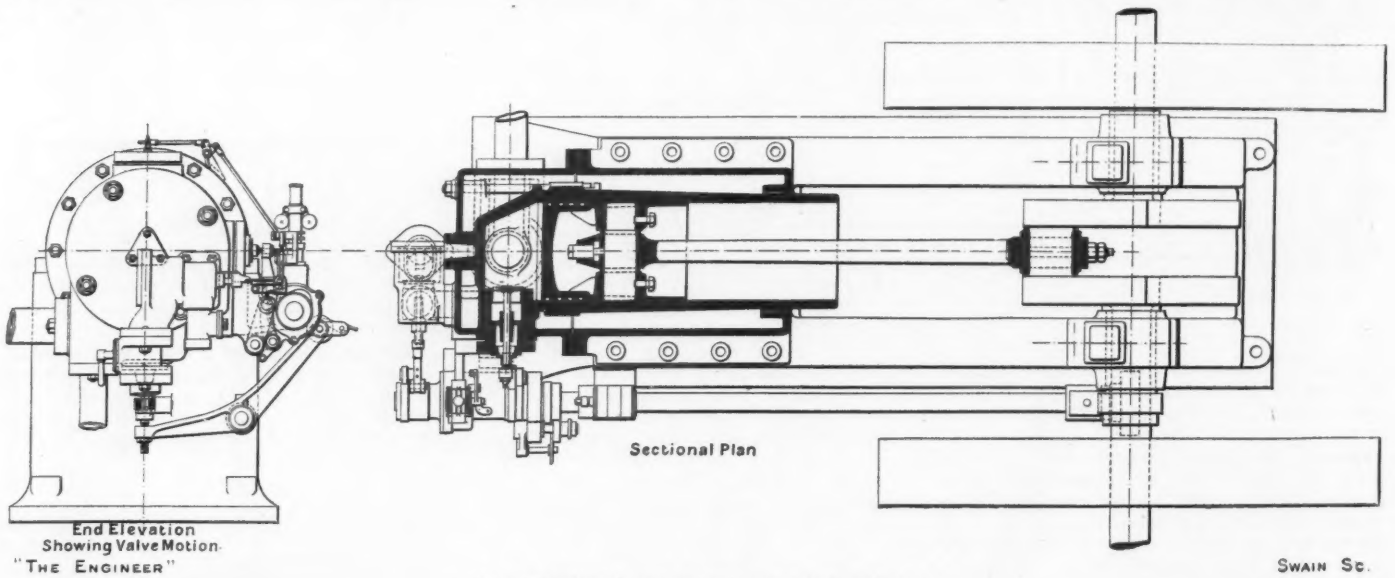


Fig. 20—GARDNER'S ENGINE—END VIEW AND SECTION

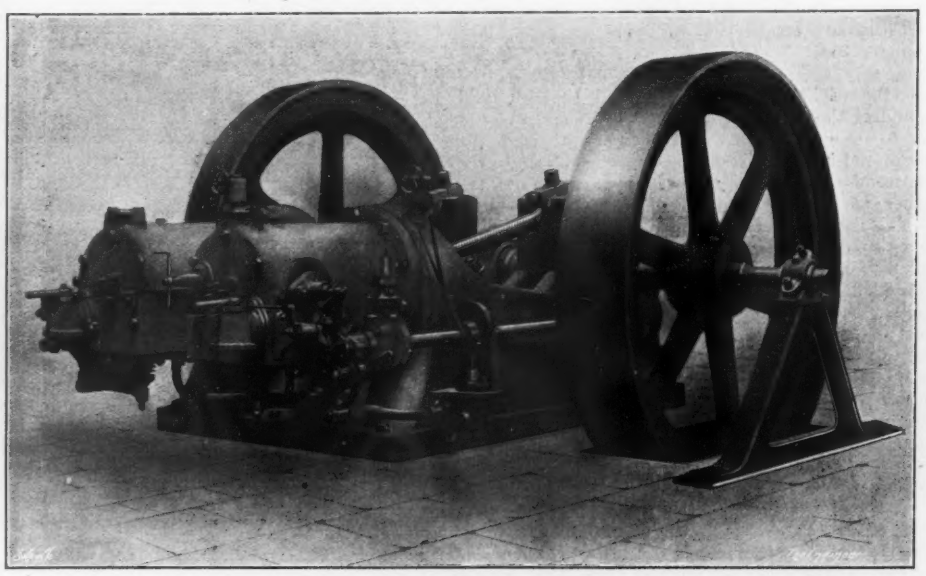


Fig. 21—DUDBRIDGE TWO-CYLINDER ENGINE

engaging with lugs suitably placed on the liner. The water-tight joint at the front end of the liner is a combined fitted and rubber ring joint. The piston is of the ordinary trunk type with "spring" rings.

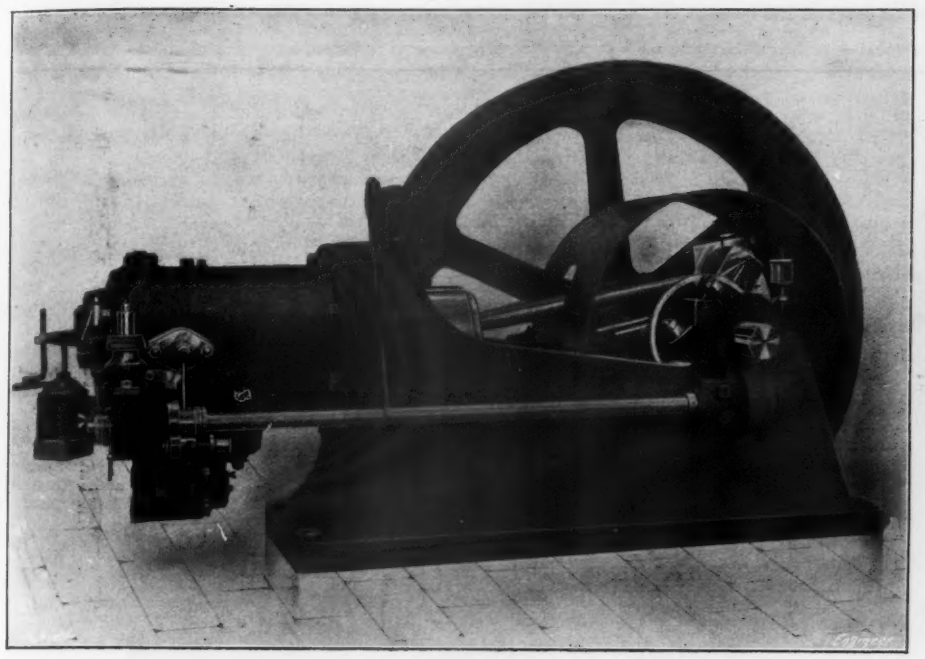


Fig. 22—DUDBRIDGE SINGLE ENGINE

Adjustment for wear is provided at the small end of the connecting-rod by a screw and pad bearing on the split brass bush. Lubrication of the crank pin is effected by a centrifugal oiler, consisting of an oil pocket and collector attached to the side face of the crank web. At each revolution of the crank this pocket wipes off the oil collected on a drip-plate attached to the flange of the adjacent bearing, the oil being supplied from the oil box of the main bearing. The weight of the revolving parts is balanced by means of counterweights bolted to the crank webs. The inlet and exhaust valves open directly into the combustion chamber; the inlet valve being carried in a housing which is removable for grinding or cleaning purposes. The exhaust valve is inserted, and the seating ground, when necessary, through an aperture in the top of the combustion chamber. The plug used to close this aperture is utilised to carry the electrodes for electric ignition by magneto. The gas valve is carried in a separate valve box, bolted to the rear of the combustion chamber. This valve box contains both the gas and air inlets; the gas passes through the valve and the air is admitted behind the valve, the mixture then passing to the inlet valve through a port formed in the combustion chamber casting. A gas cock is provided for the adjustment of the supply of gas, and an air cock is provided on the air pipe for a similar purpose. The valves are operated by cams and levers in the usual manner from the side shaft. The gas valve lever has attached at its upper end a pivoted finger; this finger operates the gas valve, and is under the control of the governor. Speed regulation is thus effected by cutting out the gas supply, air only being aspirated by the engine on cut-out strokes. The governor is of the usual centrifugal ball type, and the speed of the engine may be adjusted by means of a variable spring resistance. A secondary exhaust cam and bowl is provided to relieve the compression when starting, which is thrown out of action as soon as the engine has commenced to work. The ignition is effected either by the ordinary heated tube or by electric spark generated by a low-tension magneto machine; in the former case the time of ignition is controlled by an ignition valve, which is operated by a lever working from the cam shaft. In the latter case the magneto machine is mounted on a bracket on the side of the engine bed, and is tripped by a cam. This cam is carried by the side shaft, and engages with a lever mounted on the end of the magneto spindle. The cam is provided with a second step, which is thrown into action when starting, as by this means the point of ignition is retarded and any danger of firing before the dead centre is passed is removed. This secondary step is thrown out of gear when the engine commences to work. The break in the contact between the electrodes carried in the plug in the top of the combustion chamber is effected at the same time as the trip of the armature, by means of a link connecting the armature lever to the lever

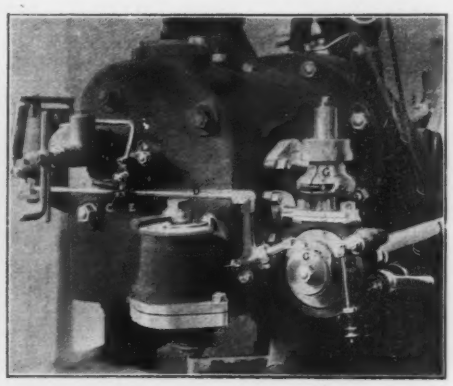


Fig. 25—BREECH END DUDBRIDGE ENGINE

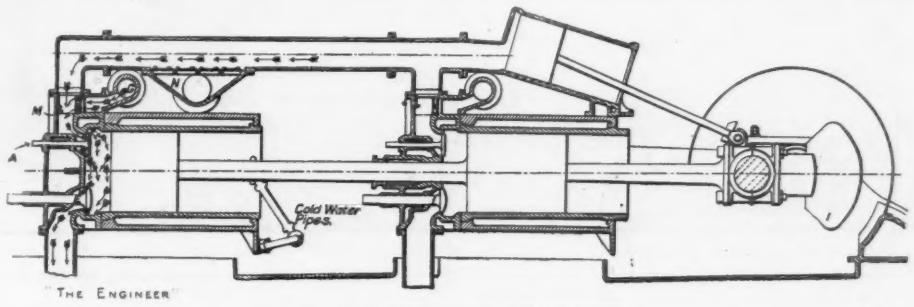


Fig. 23—PREMIER SCAVENGING ENGINE

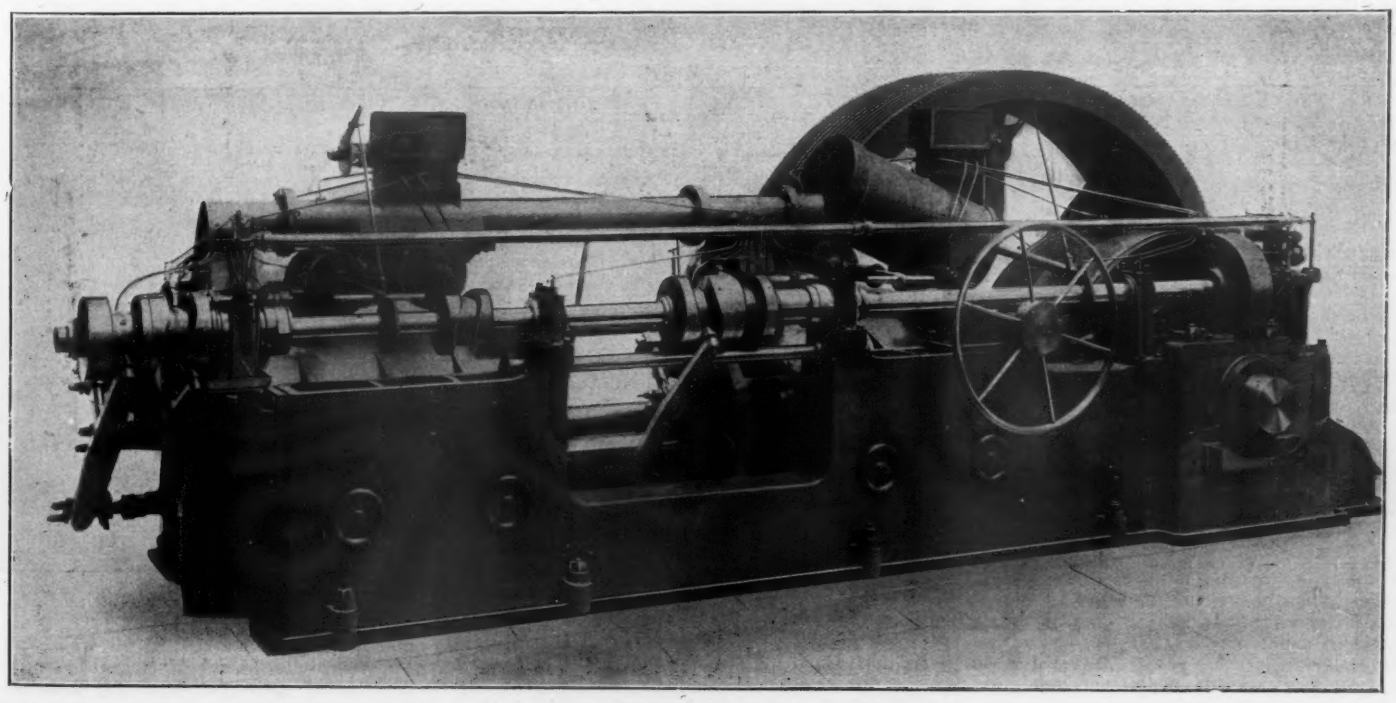


Fig. 24—TWO-CYLINDER PREMIER ENGINE

on the movable electrode. The larger engines are started either by an air compressor and receiver with starting and check valves on the engine, or by compressing the gas directly into the combustion chamber, by means of a hand pump. In the latter case the piston commences to move as soon as sufficient compression is attained, the magneto trip motion acts, the charge is fired, and sufficient momentum is acquired to start the usual working cycle.

Two types of engines made by the Dudbridge Iron Works, Limited, of Stroud, are illustrated in Figs. 21 and 22. They closely resemble each other, and one general description will apply equally to both. The difference is that one is a single engine, and the other is duplex. The Otto cycle is used, and hence the pistons receive an impulse only every second stroke; but in the duplex engine, although the cranks are side by side, and the pistons move in and out simultaneously, explosion takes place in one whilst suction is occurring in the other. Thus the crank shaft receives a thrust during part of every revolution, and a more steady turning movement results. This is particularly desirable when the engine is to be coupled direct to an electric generator; but by using a heavy fly-wheel, steady running is secured even in a single engine such as that shown in Fig. 22. The two wheels shown in Fig. 21 have been discarded in a later design for a single wheel of larger size and provided with a good out-board bearing. This engine develops 130 horse-power on the brake. It is started by air compressed either by a suitable pump or by the engine itself when stopping. The screw-down starting valve will be seen towards the left of the back end of the right-hand cylinder. The valve—an ordinary steel check valve—being opened, the air from the compression stroke of the engine enters a reservoir, where it is preserved under pressure till the engine is to be re-started. A half-compression cam, fitted to the exhaust levers, facilitates starting.

The single engine closely resembles either half of the double engine. An interesting view of the firing gear is given in Fig. 25. In both the engines shown the ignition is electric, but on engines of smaller size the hot tube is generally employed, unless they are intended to work with suction producers, when electricity must be used. The spark is produced by a magneto machine of the Simms-Bosch type, that is to say, one in which the armature and field magnet are fixed, and an iron shield is moved quickly between them. In order to secure a good spark, the spark gap must be opened at the precise instant, as already explained, and the object of the gear is to release the shield and open the spark gap inside the cylinder at practically the same instant. In Fig. 25, A is the magneto itself, and B the spring, in its case, which pulls the iron shield suddenly into place. It is pulled aside by the rod D and the levers shown. G is the cam, which in its revolutions first lifts the lever F, and then suddenly releases it. E is the outside lever of the contact breaker inside the cylinder. As the rod D moves suddenly to the right, the pin C fastened in it strikes E, and opens the spark gap just when the E.M.F. is most intense in the magneto, a spark jumps the gap, and the gas is ignited. The precise moment at which this shall occur can be regulated by sliding F in or out. Obviously, if it is far in the cam will release it sooner, and early ignition will take place; whilst if it is placed far out, ignition will be delayed. In order to avoid damage in case the

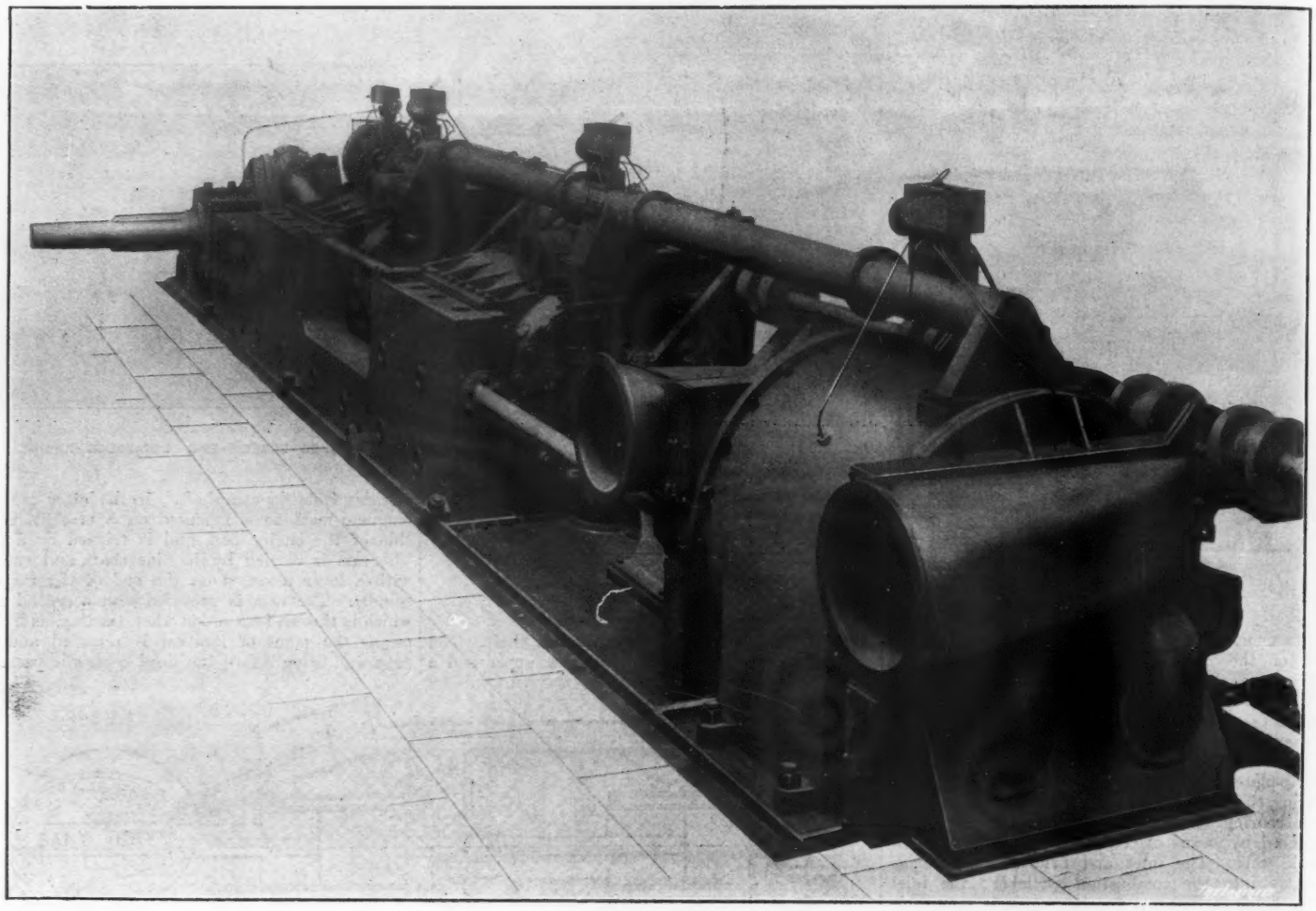


Fig. 26—PREMIER GAS BLOWING ENGINE

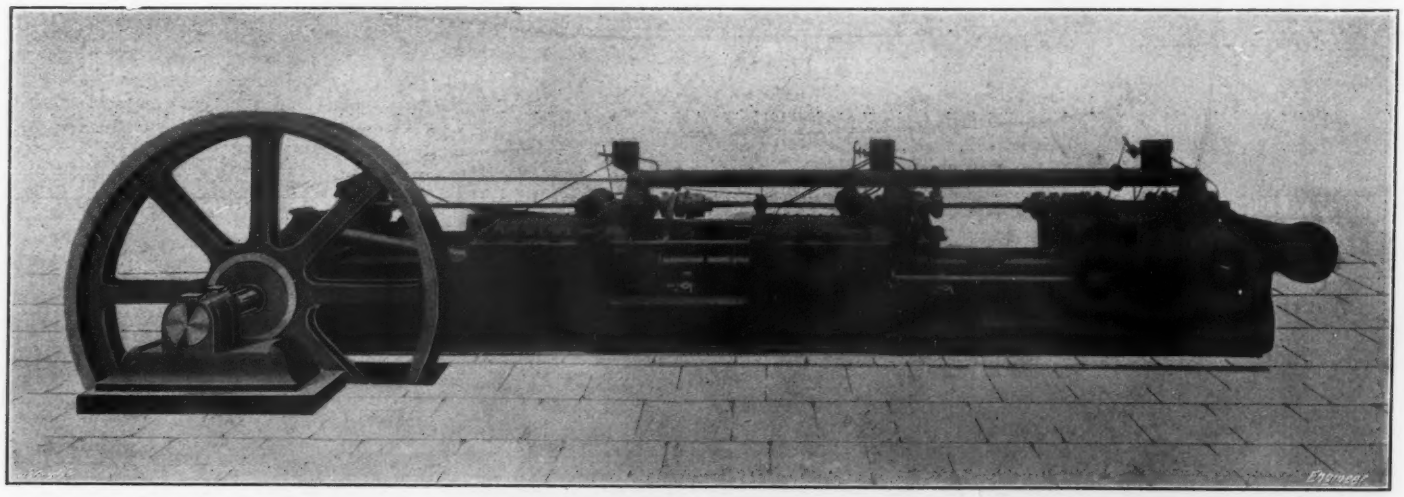


Fig. 27—PREMIER GAS BLOWING ENGINE

engine should go backwards, as occasionally occurs in starting, the cam is made on the free-wheel principle. Various modifications of this method of firing will be found in these pages, and indeed the same makers show a different design in the duplex engine. In this case, in place of the cam a small crank pin on the lay shaft lifts up the lever and releases it.

These engines are governed by throttling the gas supply through the medium of the centrifugal governor G, Fig. 25. The speed can be regulated whilst running by the nuts H.

The cylinders are made up in the usual way by fitting hard cast iron liners into outer castings, which serve as water jackets. In the duplex engine the cooling water is circulated by a small plunger pump, driven from the lay shaft. The valves open direct into the combustion chamber, all passages and ports being avoided; they are readily removed by unscrewing two nuts.

Among makers of large engines the Premier Gas Engine Company, Limited, of Sandiacre, near Nottingham, is widely known. The leading feature of the Premier design is the use of a scavenging charge—that is, a blast of pure air, which drives out from the cylinder completely the products of combustion of the preceding charge. We do not propose to go into a discussion, which is still undecided, as to whether scavenging is worth while or not; there can, we think, be little doubt that it does improve the efficiency of an engine, and the most that can be said against it is that it slightly increases the number of working parts.

A typical engine of this kind for large power, from 400 to 1200 horse-power, is the tandem single-acting engine shown in Figs. 23 and 24. It works on the Beau de Rochas cycle, but the front cylinder is taking in its charge whilst the back cylinder is making its working stroke, and *vice versâ*, so that there is an impulse given to the crank at every revolution, not at every second revolution, as in a single-cylinder single-acting engine. It must be noticed, too, that the stroke is always outwards; thus the connecting-rod is never in tension, and the brasses are always set up hard in the same direction. This is true even during the suction stroke, because even then the piston is not dragged out by the crank, but is forced out by its fellow in the other cylinder.

The scavenging is effected by opening the admission valve when the piston has nearly completed its inward stroke after an explosion, and allowing a charge of air, compressed to about 3 lb. per square inch by the inclined pump seen on top of the front cylinder, to sweep the products of combustion out through the exhaust. The pump piston and main piston are coupled to the same crank and work almost in harmony, so that both continue to move backwards

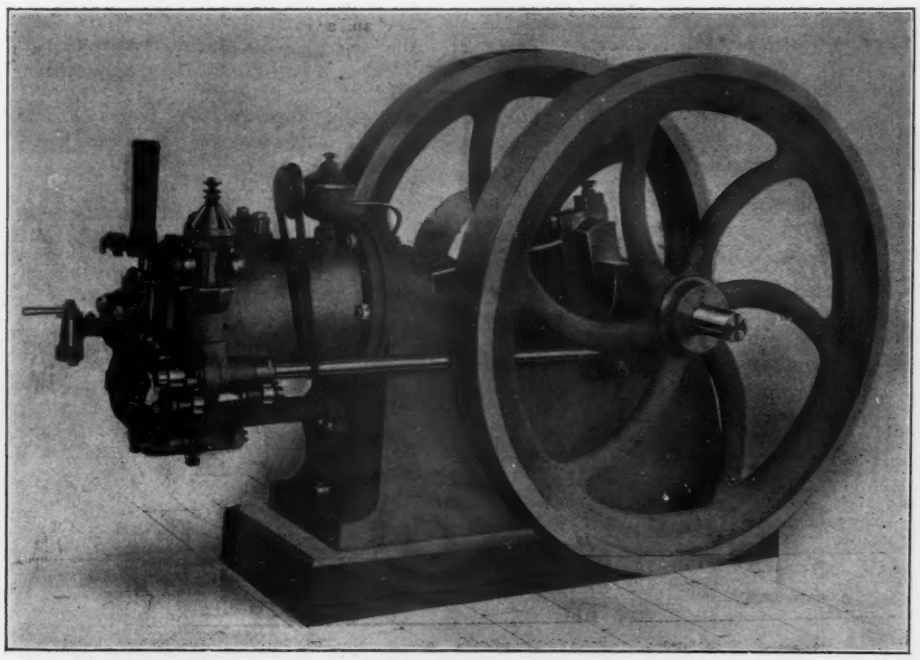


Fig. 28—8-H.P. ASHWORTH ENGINE

together, the air coming from the former blowing out the burnt gases driven backwards by the latter. The dead centre having been passed, the exhaust valve closes, and an automatic air inlet valve opens, allowing some air to pass to the pump, and some, mixed with a proper proportion of gas, which it picks up on its way, to the main cylinder. On the next return stroke this charge is compressed ready for ignition, but the air in the pump, also compressed, is allowed to enter the other cylinder. Thus the one pump acts for the two cylinders alternately. It should be made quite clear that, with the exception of the automatic valve, no special valve or gearing is involved in this arrangement, the ordinary air admission valves admitting the scavenging charge or excluding it, according to requirements. A circular grid valve is, however, sometimes used in preference to an automatic valve, and the engine shown in Fig. 24 is so fitted. This valve is contained in the right-hand cylinder on top of the main rear cylinder.

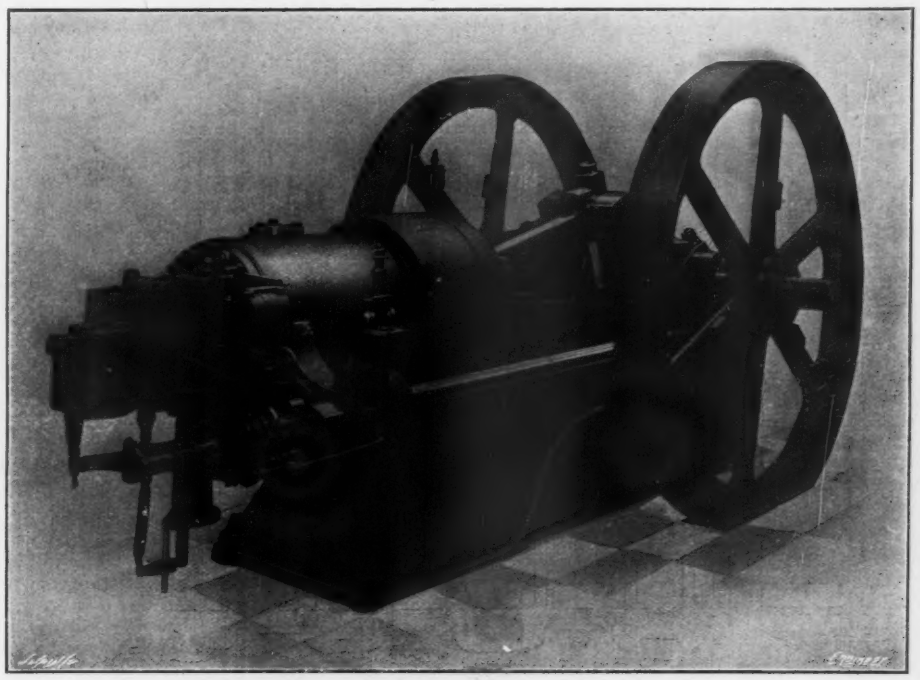


Fig. 29—GRICE HORIZONTAL ENGINE

The engine, it will be seen, is designed on very solid lines. The main frame is composed of two large girders, which support the cylinders but leave them freedom to expand. The valves are placed in the cylinder ends and open right into the cylinders. The gas valve is quite unlike that of other engines. It is of the gridiron type, and is combined with the air valve, which is of the same kind. Together the two form a large cast iron angle, both portions having slots cut in them, but the slots in the gas part fall almost opposite the bars in the air part. The object of this arrangement is the governing of the engine, which is effected by varying the stroke of this valve. It will be seen that if the valve makes its full stroke, it opens fully to gas, but at the same time nearly closes the air ports, so that a very rich charge is admitted; on the other hand, if the gas passages are but little open, the air ports are almost wide, and a weak mixture enters the cylinder. Thus the charge is varied, but without altering the compression, since, because the combined area of gas and air valves is the same in all positions of the valve, the same amount of mixture enters the cylinder. The movement of the valve is varied by the governor, which raises or lowers a thrust-blade nearer to or further from the fulcrum of a lever with a constant angular stroke. The lever is operated by a cam on the lay shaft, and the valve is closed by four springs, of which any two are powerful enough to do the work alone. The cam shaft shows very clearly in the illustration. The cam nearest the cylinder operates the admission valve; the other, by the long cross lever shown, opens and closes the exhaust valve, which is of the ordinary poppet type, but is closed positively, as is also the admission valve, two springs, which have a motion not exceeding $\frac{1}{16}$in., ensuring the seating of the valve without straining the valve gear. The governor is of the centrifugal type, and is driven by screw gear from the crank shaft. It is placed at the forward end of the engine, and the rod from it, for operating the control gear, is carried along the engine inside the hand rail. The large hand wheel works a barring gear for bringing the crank round to a proper starting point. Both the pistons and the exhaust valves are water-cooled, the water entering the latter through suitable elbow pipes.

A section of an engine of this type is given in Fig. 23, which shows the action of the scavenging charge in the back cylinder. The piston is right home; the main admission valve A is open, and the air coming along the trunk from the pump is blowing right through into the exhaust. An instant later the exhaust valve E will close, and the mixing valve M will open, air will be drawn through the automatic valve-box N and the gas pipe G, and an explosive charge will be formed in the cylinder. Whilst this is happening in the back cylinder, the other piston has compressed its charge, which, at the moment shown, is on the point of being ignited.

A fine example of a gas blowing engine made by this company is illustrated by Figs. 26 and 27. In a general way it is just like the tandem engine, Fig. 24. The piston-rod is extended through the cover of the back cylinder, and connected to a crosshead, to which is attached also the piston-rod of the blowing tub, which is placed in line with and behind the motor cylinders. A guide supports this crosshead, and the piston of the blowing tub has a shoe formed on its lower side, thus providing a large bearing surface to take the weight. The guide is carried on a large cast iron base plate forming a tray which collects all the waste oil from the working parts between the motor cylinder and blowing tub. The outboard bearing shown in the illustration was put in "to taste" by the artist, and is not to be taken too literally. The top of the blowing tub is connected to the motor cylinders by a pipe which conveys the air required for combustion and for scavenging. This pipe opens into the blowing tub near its back end through ports which are covered by the blowing piston shortly before the completion of its back stroke, and opened shortly after the commencement of its suction stroke.

The action is, therefore, as follows:—At the beginning of the out-stroke the pressure of air in the pipe

is slightly above that of the atmosphere, but as it is flowing towards the motor cylinder which has just made its exaust stroke the pressure is falling, and this, combined with the reversal of motion of the piston, soon brings it to atmospheric pressure. About this time the blowing piston uncovers the ports and allows a free entrance of air, which, coming into the blowing tub by the inlet valves, passes thence along the pipe to the cylinder which is making its suction stroke—viz., the one which has just completed its exhaust stroke—and thus furnishes the air for combustion.

In the return stroke the air is compressed in the blowing tub, and therefore into the pipe till the blowing piston covers the ports. Previous to this, the admission valve of the other motor cylinder—which is now making its exhaust stroke—has been opened by its cam, and some air thus allowed to flow into the combustion chamber, displacing the products of combustion through the open exhaust valve. When the blowing piston covers the ports, the supply of air is stopped; but as there is some compressed in the air pipe, the flow through the combustion chamber is kept up till after the crank has passed the centre, and thus the scavenging is completed. The amount of air thus used for scavenging is about 3 per cent. of the volume delivered by the blowing tub.

The valves of the blowing tub are of the gridiron type placed on the cylinder covers, the suction valves being below, and the delivery valves above the centre line. All these valves are operated in a positive manner from grooved cams fixed on the continuation of the shaft which operates the valve gear of the motor cylinders, and thus quick opening and closing are obtained, and a large and straight passage given both for inlet and delivery. In addition, there are safety spring-loaded valves in each cover to prevent excessive pressure in the blowing tub should it be accidentally put to work while the shut off valve on the delivery main is closed, or any other cause arise to block the outlet.

The engine is started by compressed air, and it is, we are informed, very certain and quick in getting away. While starting, the suction valves of the blowing tub are kept open and the delivery valves closed, which leaves the engine temporarily practically free from load.

The motor cylinders are 38in. diameter, and are capable of about 1000 horse-power with blast furnace gas, and the blowing tub 72in., the common stroke being 4ft., and the speed from 75 to 85 revolutions per minute, and as the clearance in the blowing tub is only 3 per cent., it delivers almost the full volume swept by the piston. This ingenious method of using a supply of air from the blowing tub dispenses with the need of the scavenging cylinder, and simplifies the engine for this particular purpose.

A gas engine which is familiar to managers of gas works is the Grice engine, Fig. 29, made by Wm. Grice and Sons, Limited, of Birmingham. It is made in sizes from 2 brake horse-power up to 150 brake horse-power, and is of the horizontal pattern. The bed is a girder section casting, into which the water jacket fits. The valve chamber, which is a separate casting, has been recently re-designed to give greater accessibility than heretofore, and now by taking off the glands on the top of the valve chamber, the valves and seats are exposed at once In engines of larger size a condenser base is provided, which supports the jacket throughout its whole length, leaving only the valve chamber overhanging.

Another engine of conventional design is that made by Mr. Elijah Ashworth, of Collyhurst, Manchester, and of which we illustrate, Fig. 28, the 8 indicated horse-power size. The construction will be quite obvious from an examination of the engraving. Each valve is provided with its own cap or cover so that it may be removed for inspection without interfering with the others. A centrifugal governor is used, acting in the usual way with a thrust rod upon the throttle valve. The same firm makes a series of nine engines, varying from 2 horse-power, with a cylinder $3\frac{3}{8}$in. diameter, by 6in. stroke, running at 320 revolutions per minute up to 50 indicated horse-power, with a cylinder, 12in. by 18in., and making 185 revolutions per minute. The engine illustrated has a cylinder 6in. by 10in., and the speed of revolution is 240.

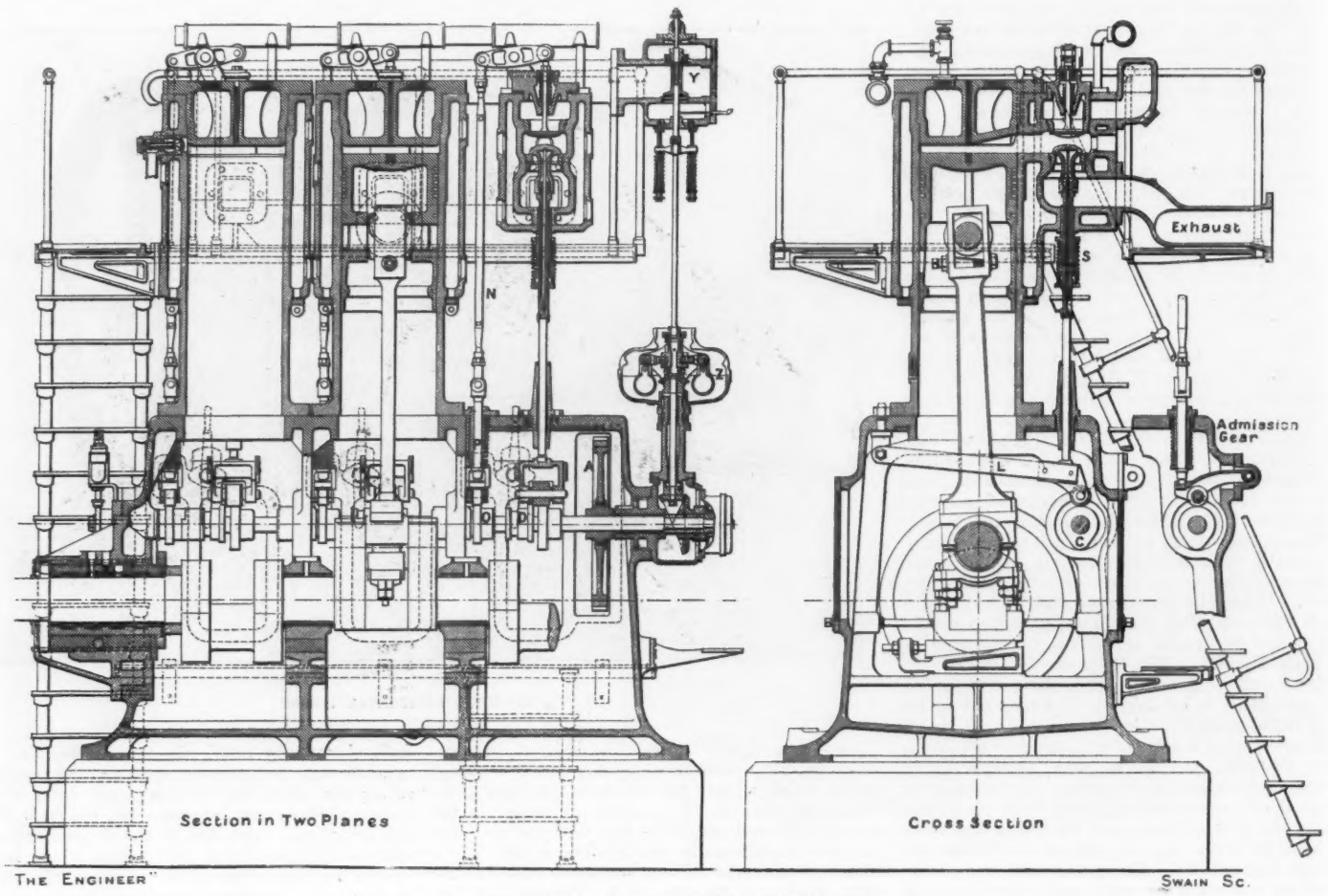


Fig. 30—WESTINGHOUSE THREE-CYLINDER VERTICAL ENGINE

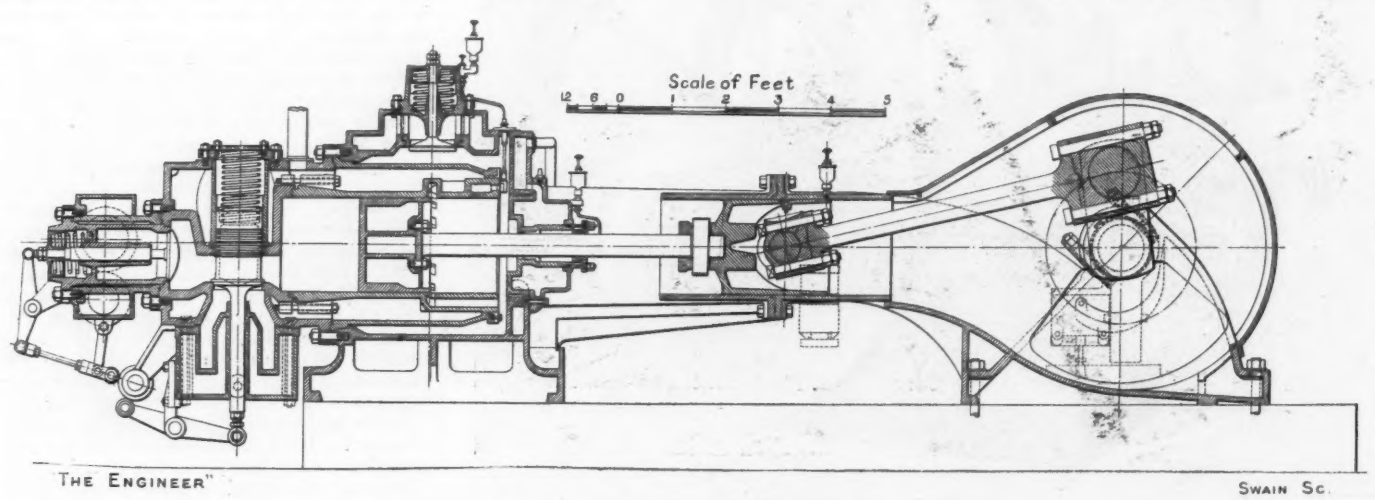


Fig. 31—NATIONAL SUPER-COMPRESSION ENGINE

A small gas engine, intended largely for domestic service, and in which great simplicity is therefore aimed at, is the Ideal, made by Hardy and Padmore, Limited, of Worcester. A plan section through the gearing, reproduced in Fig. 32, shows how it differs from other engines. The usual shaft driven by gearing from the crank shaft is omitted, and in its place a short shaft is mounted at the breech of the cylinder and driven by a chain and sprocket wheel. The cams are on this shaft and work right on to the

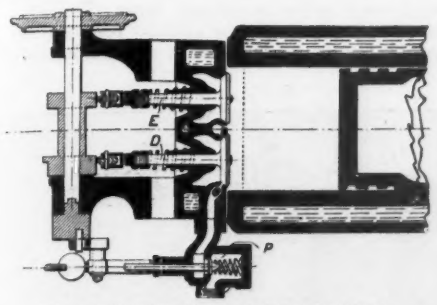
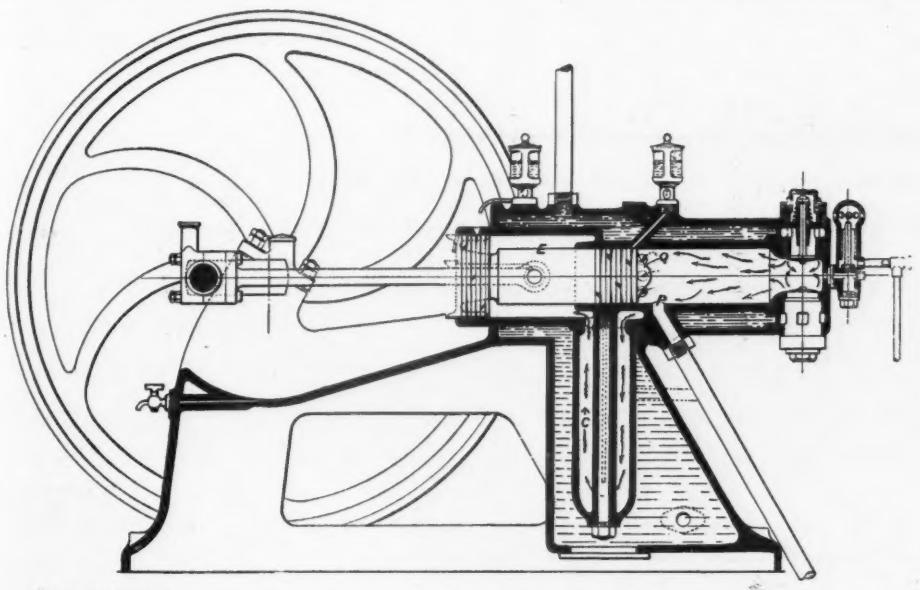


Fig. 32—HARDY AND PADMORE'S ENGINE

levers and rollers for operating the valves. The engine is governed by hit-and-miss gearing. P is the gas valve, D the admission valve to the cylinder, and E the exhaust valve. We understand that the largest engine made with this class of gearing developes 8 horse-power on the brake, running at 300 revolutions per minute.

A small two-cycle engine—that is, one that gives an impulse every revolution—is made by Thos. Glover and Co., Limited of 49, Queen Victoria-street, and is known as the "Gothic." It is illustrated by a section, Fig. 33. The principle of its action will be readily understood. Gas and air, having entered through the two automatic valves shown, are compressed and fired. The piston goes outwards under the pressure produced by explosion until a port P open to the atmosphere is uncovered; through this the gases rush with sufficient velocity to reduce, it is claimed, the pressure in the cylinder slightly below atmospheric pressure. Going still further, the ports Q are uncovered. They lead to a condenser C, which is always surrounded by cold circulating water, and thence to the annular space E, in which a partial vacuum has been produced by the outward movement of the big piston shown. The charge by entering the condenser and passing up to the cylinder E reduces the pressure in the working cylinder below atmospheric, and hence a new charge of gas and air enter ready for the next stroke. The only positive valve is that which opens the gas supply, and which is driven by an excentric through a hit-and-miss governor of the pendulum type. If the governor cuts out the gas supply is closed, and the cylinder is scavenged by a charge of air only. The products of combustion left in the cylinder E and the condenser



"THE ENGINEER"

Fig. 33—GLOVER'S TWO-CYCLE ENGINE

C are driven out through a suitable pipe and non-return valve into the exhaust.

In our introductory remarks we mentioned that the National Gas Engine Company, of Ashton-under-Lyne, were experimenting with an engine in which a charge of air was injected into the cylinder at a few pounds pressure just before compression began. A section of an engine of this type is shown in Fig. 31. The idea, in Mr. Clerk's—the inventor's—own words, is to keep up mean pressures while keeping down flame temperatures in order to avoid the well-known liability of heavily loaded gas engines to overheating and pre-ignition. The illustration is taken from a paper read at the British Association, and we cannot do better than give Mr. Clerk's own description:—"In this engine the back end of the cylinder is arranged as a four-cycle motor of normal type; the front end is arranged as an air-pump, and is closed with a cylinder cover, through which a piston-rod passes from a crosshead guide of usual construction. One air valve is operated at the pump end from the cam shaft. On one back stroke a charge of air is taken into the cylinder, the valve is closed, and on the out-stroke this air charge is compressed into a reservoir forming the clearance space between the piston and the cylinder head. Ports overrun by the piston communicate with this clearance space, which is well water-jacketed, and the pressure causes the air to flow into the cylinder when the charging stroke is nearly complete. In this way the pressure of the charge is raised to about 7 lb. per square inch. The pressure in the front reservoir is raised to about 16 lb. per square inch, but the fall is only sufficient to raise the

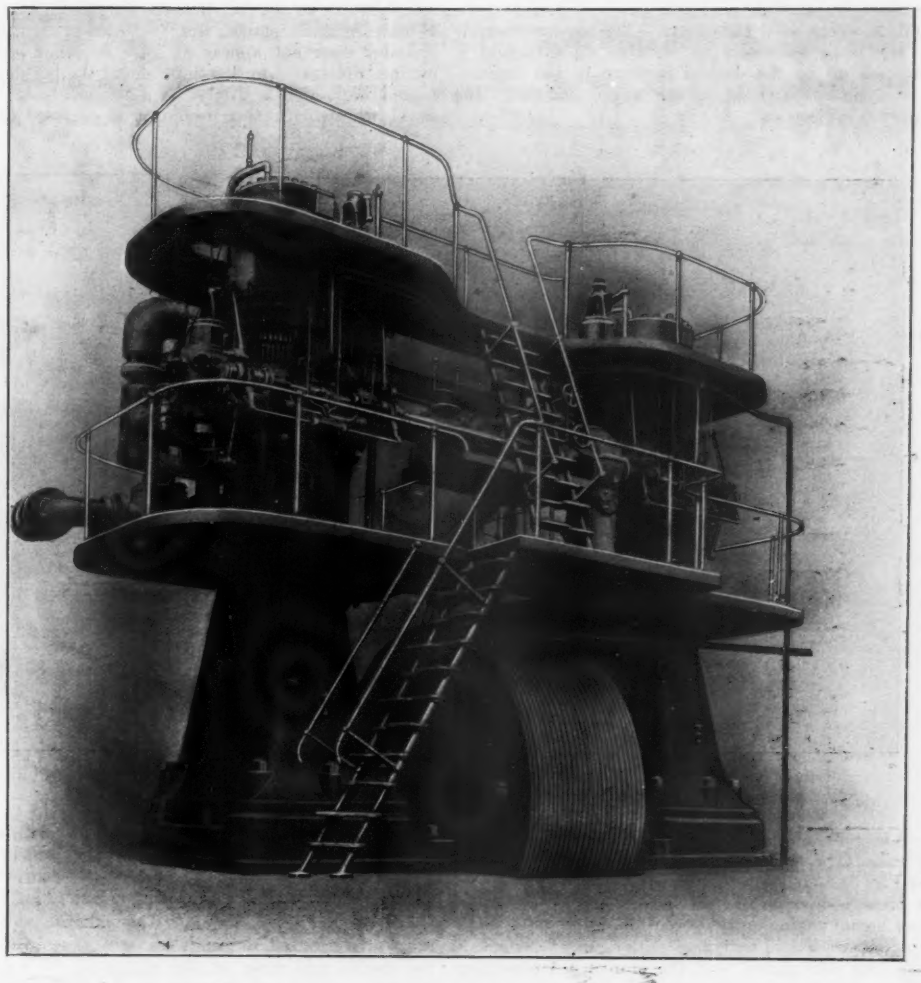


Fig. 34—WESTINGHOUSE TWO-CYLINDER GAS ENGINE

pressure within the cylinder to about 7 lb. above atmosphere. The reservoir still contains some air at a little above 7 lb. pressure, and this air is used on the next exhausting stroke to act as a scavenging air charge to displace the exhaust products from the cylinder and secure that no exhaust remains to form part of the further charge. The engine is thus not only a super-compression engine, but it is a scavenging engine. The pump side is arranged to draw air in on one stroke only—that is, the valve only opens once in two revolutions. One air charge is sufficient both for the purpose of super-compression and scavenging. Calculation from diagrams proves clearly that a high mean pressure of over 100 lb. per square inch is obtained with the very low maximum temperature of 1200 deg. Cent. The effect of this reduction of temperature in the smooth working of the engine is most remarkable. The tendency to pre-ignition or overheating is found to be entirely absent. Notwithstanding the fact that no watered piston is employed, the engine runs with perfect certainty at full load, with consecutive ignitions, at 160 revolutions per minute."

Whilst, as these pages show, many firms have taken up the construction of vertical engines as a supplement to horizontal engines, we believe the Westinghouse Company stands alone in making its principal design vertical. Of the three photographs of the Westinghouse engine here reproduced—Figs. 34, 35, and 36—the last two illustrations are different views of the same engine. This is the three-cylinder type, and a sectional drawing of it is given in Fig. 30. Engines up to 250 horse-power are built on these lines. The design, like that of all vertical gas engines, owes much to the high-speed steam engine. The crank chamber is entirely boxed in, and lubrication is effected by the splash from an oil bath.

The Otto or Beau de Rochas cycle is used, and the speed is regulated by throttling the charge, such regularity being maintained that direct coupled and alternating generators can, we are told, be operated in parallel with certainty. At Walthamstow engines developing in all some 2000 horse-power have been installed, and at Faversham and Limerick other engines of the kind are also generating electricity.

The engines are started by compressed air. The compression plant is simple, and is modified to suit the conditions. One cylinder is for the moment converted into an air-motor cylinder by altering the action of the gas and exhaust valves, until explosion takes place in one of the other cylinders, to which a proper mixture of air and gas is admitted. Once the engine has got away, the first cylinder is changed over to its normal condition, gas is admitted to it, and it works with the others. The compressed air is stored in reservoirs of suitable capacity, and is pumped up to the desired pressure by the engine. The cylinders and heads are water jacketed; the ignition is electric.

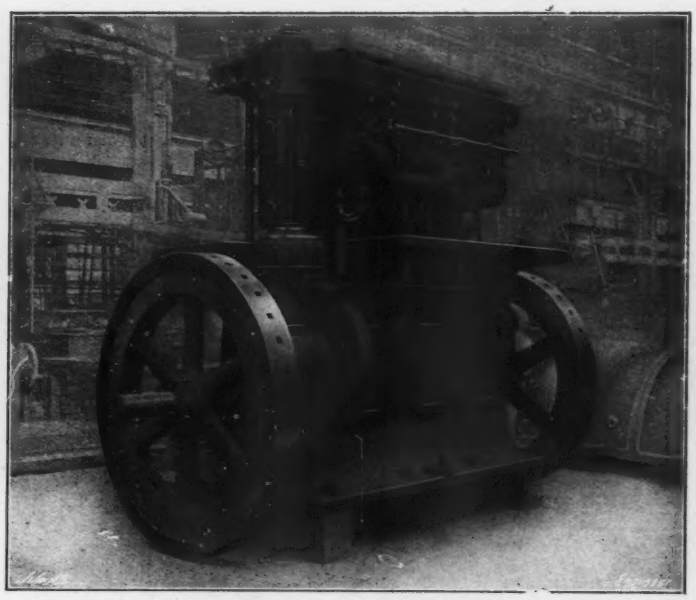


Fig. 35—WESTINGHOUSE ENGINE—BACK

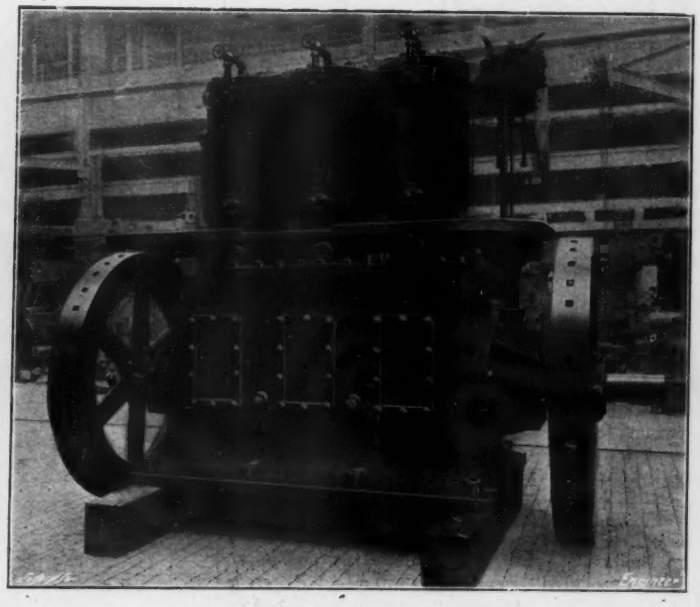


Fig. 36—WESTINGHOUSE ENGINE—FRONT

A larger engine—550 brake horse-power—still of the vertical type, but having only two cylinders, is shown in Fig. 34. It might easily be taken at first sight for a cross compound vertical steam engine, so closely has steam engine outline been followed. The crank shaft is carried in two large self-aligning bearings in the two sole plates, and the cranks are overhung. The cylinders are double-acting, and the piston has a rod and crosshead like a steam engine. The valves are placed on the sides of the cylinders, where they are readily accessible, and are operated by a horizontal cam shaft, driven by a vertical shaft and gearing. The speed is controlled by throttling, as in the smaller engines, and ignition is effected electrically. Forced lubrication is used, and the engine is started up by compressed air. The cylinder and cylinder covers, the pistons and piston-rods, are all water cooled, the water entering and leaving the latter through rocking levers. This engine has been built to run a mill, and is fitted with a large rope fly-wheel. Its steadiness of running is said to be remarkable.

The drawing of the three-cylinder engine which appears in Fig. 30 may be found a little difficult to follow, owing to the fact that the longitudinal section is made in three planes, and the third or right-hand cylinder does not appear at all. In other vertical engines illustrated in this Supplement the lay shaft is placed high, and is driven by a vertical shaft and bevel wheels. In this design it is enclosed in the crank chamber, and is connected with the main shaft by a pair of three-to-one wheels, of which the larger is seen at A keyed to the lay shaft. The valves are placed in a box behind each cylinder, as shown in the cross-section. The exhaust valve is the lower; its rod descends straight down through two guides and rests on the extremity of a lever, which is raised and lowered at the proper time by the cam C. The spring S serves both to keep the valve shut and to keep the lever pressed against the cam. The valve itself is hollow, and may be water cooled. The admission valve is raised against its seat by a spring, and is depressed to admit the explosive mixture by the lever, the rod N, and the plunger P, which is moved up and and down, through the medium of a short lever—see detail in end view—by the cam Q. All three cylinders are fac-similes of each other, with the exception that a special starting valve is fitted to that on the left side.

The mixture of gas and air enters through the two valves in the box Y, which are kept nominally off their seats by the two springs seen below the box. If, however, the speed becomes excessive, the governor Z pulls down the rod and throttles the charge.

In order to facilitate starting, each cylinder is provided with a sliding cam D, which can be moved by a hand lever under the exhaust valve. The cam is so shaped that it holds the exhaust open during the greater part of the in stroke of the piston, and thus reduces the compression. Once the engine is away, this cam is slid out of place, and the normal action begins.

It will be noticed that the cylinders are quite independent of each other, and that the covers are hollow and very deep, so that a good volume of water may circulate through them. Attention may be directed to the method of aligning the two centre shaft crank bearings, which is seen in the end section. The piston is, it will be noticed, of good length, and the position of the rings may be observed and contrasted with the arrangements in other engines. Attention may also be directed to the fact that the cylinders, water jacket, and valve box are in one casting.

MACHINE TOOL DESIGN.

By Professor J. T. NICOLSON, D.Sc., M. Inst. C.E, and Mr. DEMPSTER SMITH.

No. IX.*

In our last article we discussed, with a worked out example, the width of belt for a given lathe, and observed what a small difference in width is produced by altering the number of cone steps, and remarked that it is quite different, on the other hand, when the cover the case we are now considering, of *the cone mounted upon the spindle and coupled directly to it for the highest spindle speeds*, we see that for lathes above 18in. centres the widths of belt required to pull the standard cut (area $= h^2/6400$) at the ordinary speeds for carbon steel of 16ft. per minute and less, become extravagantly great, and we are driven to the conclusion that *for lathes using carbon steel above 16in. or 18in. centres the cone must be mounted on a back shaft and geared to the lathe spindle by a pair of gears when the highest spindle speeds are being employed.*

The values of K and L may be most concisely given as follows :—

Linear formulæ for belt widths for common lathes with cone on spindle; standard cut to be taken on diameter = 2 h

No. of back gears.	Formula.
2	B = 0·78 h − 3·25in.
3	B = 0·80 h − 5·6in.
4	B = 0·82 h − 7·2in.

If we compare these correctly determined values of the

TABLE XIV.—*Table of Belt Widths (B) for Lathes using Carbon Steel. Cones Mounted on Spindle. Standard Diameter = 2 h. Two Countershaft Speeds, Three or Four Steps on the Cone. Two, Three, or Four Back Gears.*

h ... ... =	6		9		12		15			18				21				24					1
N_g ... ... =	305		204		152		122			102				87				76·3					2
$\frac{N_g}{N_t}$	49·4		51		53·3		56·5			60				64·5				69·5					3
Number of back gears	2	2	2	2	2	3	2	3	4	3	3	4	4	3	3	4	4	3	3	4	4		4
m	3	3	3	3	3	4	3	4	5	4	4	5	5	4	4	5	5	4	4	5	5		5
q	3	4	3	4	4	3	4	3	3	3	4	3	4	3	4	3	4	3	4	3	4		6
s	18	24	18	24	24	24	24	24	30	24	32	30	40	24	32	30	40	24	32	30	40		7
Log. $r = \frac{\log. \frac{N_g}{N_t}}{s-1}$	·0996	·0736	·1002	·0743	·075	·075	·0762	·0762	·0605	·0775	0·575	·0614	·0456	·0785	·0583	·0624	·0464	·0802	·0595	·0636	·0473		8
r ... ... =	1·258	1·185	1·260	1·187	1·189	1·189	1·192	1·192	1·149	1·195	1·141	1·152	1·111	1·198	1·144	1·154	1·113	1·203	1·147	1·158	1·115		9
$2q-1$	5	7	5	7	7	5	7	5	5	5	7	5	7	5	7	5	7	5	7	5	7		10
r^{2q-1}	3·148	3·275	3·177	3·312	3·350	2·371	3·415	2·404	2·006	2·441	2·526	2·028	2·085	2·469	2·560	2·051	2·113	2·518	2·609	2·08	2·143		11
$V_t = \frac{48}{\sqrt{h}\, r^{2q-1}}$	6·2	6·0	5·0	4·8	4·1	5·8	3·6	5·1	6·2	4·6	4·5	5·6	5·4	4·2	4·1	5·1	5·0	3·9	3·7	4·7	4·6		12
$P = \sqrt{6\sqrt{h}\left(7 + \frac{V_t}{14}\right)}$	28·5		31·2		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		13
$P = \sqrt{6\sqrt{h}\left(7·5 + \frac{V}{10}\right)}$	—		—		37		39		40	41				43				44					14
2 P	56		62		73		78			82				85				88					15
Horse-power CHP	·855		1·85		3·16		4·66			6·3				8				9·7					16
$B = \frac{550 \text{ CHP}}{2 \text{ P } V_t}$	1·3	1·4	3·2	3·4	5·8	4·1	9	6·4	5·3	9·1	9·4	7·6	7·5	12·2	12·7	10·2	10·3	15·5	16·2	12·7	13·2		17
$A = 6\sqrt{h}$	15		18		21		24			26				28				30					

number of back gears (that is, $m - 1$) and m are altered. The number of speeds rises proportionally with the number of back gears, and r is correspondingly diminished. But in the term r^{2q-1}, the power $2q - 1$ remains the same, because q is unaltered, and r^{2q-1}, therefore gets less with r. Thus V_t is materially changed by altering m; and the belt width is considerable affected.

This is clearly shown in the tables. Take, for example, the 18in. lathe in Table XIV. By increasing the number of cone steps from three to four, the belt width is changed only from 9·1in. to 9·4in. with three back gears, and from 7·6in. to 7·5in. with four back gears; whereas, keeping the number of cone steps the same, say four, and increasing the number of back gears from three to four, the belt width is brought down from 9·4in. to 7·5in., or by nearly 2in. From this we are to infer that, as the size of lathe increases, it is necessary to put in more back gears in order to keep down the width of the belt to a reasonable figure, and this fact becomes very evident from a mere inspection of any of the tables.

Refering especially to Tables XIV. and XV., which

* No. VIII. appeared June

In Table XIV. the requirement has been fulfilled that the standard cut shall be taken upon work of face-plate diameter ($2h$). Table XV. has been calculated on the assumption that this cut will never be taken on work of diameter which cannot be swung over the saddle. This diameter is found to be $2(h - \sqrt{h})$, the depth of the saddle being about equal to $\sqrt{h}$, and this is the fundamental datum underlying Table XV.

The belt widths obtained by calculations precisely the same as that given above, for these two assumptions (standard diameters $2h$ and $2(h - \sqrt{h})$ respectively) have been plotted as ordinates on a base of height of lathe centres in Fig. 23, which we repeat from our VIII. article.

The resulting curves show an approach to linearity which is little short of surprising, when the complexity of the formula for the belt width in terms of the height of centres is considered.

They are all represented by a formula of the type :—

$$B = K h - L$$

if the spots representing belt widths for different sizes of lathe *with the same number of back gears* are connected together.

TABLE XV.—*Table of Belt Widths for Lathes using Carbon Steel, Cone Mounted on Spindle. Standard Diameter = 2 (h − √h). Two Countershaft Speeds. Three or Four Cone Steps. Two, Three, or Four Back Gears.*

h ... ... =	6″		9		12		15			18				21				24					1
N_g ... ... =	305		204		152		122			102				87				76·3					2
$\frac{N_g}{N_t}$ ... ... =	29		34		38		41			46				49·2				55					3
Number of back gears ... ... =	2	2	2	2	2	3	2	3	4	3	3	4	4	3	3	4	4	3	3	4	4		4
m ... ... =	3	3	3	3	3	4	3	4	5	4	4	5	5	4	4	5	5	4	4	5	5		5
q ... ... =	3	4	3	4	4	3	4	3	3	3	4	3	4	3	4	3	4	3	4	3	4		6
s ... ... =	18	24	18	24	21	24	24	21	30	24	32	30	40	24	32	30	40	24	32	30	40		7
Log. $r = \frac{\log. \frac{N_g}{N_t}}{s-1}$ ... ... =	·086	·0635	·09	·0666	·0686	·0686	·07	·07	·0556	·0723	·0536	·0574	·0427	·0736	·0546	·0583	·0433	·0757	·0562	·06	·0446		8
r ... ... =	1·219	1·157	1·23	1·166	1·171	1·171	1·175	1·175	1·137	1·181	1·132	1·141	1·104	1·185	1·134	1·144	1·105	1·191	1·139	1·148	1·109		9
$2q-1$	5	7	5	7	7	5	7	5	5	5	7	5	7	5	7	5	7	5	7	5	7		10
r^{2q-1}	2·692	2·783	2·818	2·925	3·021	2·203	3·09	2·239	1·897	2·299	2·372	1·936	1·99	2·333	2·411	1·956	2·01	2·391	2·474	1·995	2·052		11
$V_t = \frac{48}{\sqrt{h}\, r^{2q-1}}$	7·3	7·05	5·7	5·48	4·6	6·3	4	5·6	6·5	5	4·75	5·8	5·7	4·5	4·35	5·4	5·25	4·1	4·0	5	4·9		12
$P = \sqrt{6\sqrt{h}\left(7 + \frac{V_t}{11}\right)}$	28·5	28·4	31·6	31·3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		13
$P = \sqrt{6\sqrt{h}\left(7·5 + \frac{V_t}{10}\right)}$	—	—	—	—	36·2	37·5	38·2	39	39·2	40·4	40·2	40·7	40·7	41·7	41·6	42·2	42·2	43·0	43·0	43·5	43·4		14
2 P	57	56·8	63·2	62·6	72·4	75	76·4	78	78·4	80·8	80·4	81·4	81·4	83·4	83·2	84·4	84·4	86·0	86·0	87·0	86·8		15
Horse-power CHP	·855		1·85		3·16		4·66			6·3				8				9·7					16
$B = \frac{550 \text{ CHP}}{2 \text{ P } V_t}$	1·1	1·2	2·8	3	5·2	3·7	8·3	5·9	5	8·4	9	7·25	7·5	11·75	12	9·75	10	15	15·5	12	12		17
$A = 6\sqrt{h}$	15		18		21		24			26				28				30					18

three back gears) with cone mounted on spindle is not capable of taking the standard cut of depth $\frac{h}{40}$ and traverse $\frac{h}{160}$, at a speed of 16ft. per minute, on work either of face-plate diameter or even of a diameter which can be swung over the saddle. Belt tension of 200 lb. per inch and over would be required to enable them to do so.

In some cases which have been examined, where the cone is mounted on the spindle, a high belt speed and a correspondingly narrow belt have been obtained by allowing large values of N_g, the maximum spindle speed, to be the

belt widths with the values commonly obtaining in practice, as exhibited by the dot and ring spots on Fig. 23, we see that the usual values are, more or less, of the right order of magnitude for lathes between 8in. and 15in. centres.

For smaller lathes the ordinarily allowed widths are *too great*, whilst for those above 15in. the belts usually supplied are *absurdly too small*. In other words, the ordinary make of lathe larger than of 15in. height of centres (and over 12in. centres in which there are less than

TABLE XVII.—*Table of Belt Widths for Lathes using Carbon Steel. Cone Mounted on Back Shaft. $R_o = \sqrt{h}$. Standard Diameter = 2 h. Two Countershaft Speeds. Four Steps on Cone. One, Two, Three, Four and Five Back Gears. Effect of Increasing Number of Back Gears upon the Belt Width.*

h ... ... =	12				18				24				36					48				60					72					1
N_g ... ... =	152				102				76·3				51					38·2				30·6					25·4					2
$\frac{N_g}{N_l}$ ... ... =	53·3				60				65·5				96·5					134·5				183					242					3
Number of back gears ... ... =	1	2	3	5	1	2	3	5	1	2	3	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	4
m ... ... =	2	3	4	6	2	3	4	6	2	3	4	6	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6	5
q ... ... =	4				4				4				4					4				4					4					6
$2q - 1$ ... ... =	7				7				7				7					7				7					7					7
s	16	24	32	48	16	24	32	48	16	24	32	48	16	24	32	40	48	16	24	32	40	48	16	24	32	40	48	16	24	32	40	48	8
Log. r ... ... =	·115	·075	·0557	·0368	·1185	·0773	·0573	·0378	·1228	·08	·0595	·0392	·1325	·0834	·064	·051	·0423	·142	·0925	·0687	·0546	·0452	·151	·0985	·0731	·058	·0482	·159	·1038	·077	·061	·05075	9
r ... ... =	1·303	1·189	1·137	1·088	1·314	1·195	1·141	1·091	1·326	1·202	1·147	1·094	1·357	1·22	1·159	1·125	1·103	1·1387	1·237	1·171	1·134	1·11	1·416	1·254	1·188	1·143	1·118	1·442	1·270	1·194	1·151	1·124	10
r^{2q-1}	6·388	3·350	2·454	1·809	6·753	3·476	2·519	1·840	7·238	3·631	2·61	1·881	8·463	4·025	2·805	2·275	1·977	9·863	4·44	3·026	2·411	2·072	12·76	4·893	3·248	2·547	2·175	12·92	5·328	3·459	2·673	2·2526	11
$V_l = \frac{48}{r^{2q-1}}$	7·53	14·3	19·6	26·6	7·10	13·8	19	26·1	6·63	13·3	18·4	25·5	5·67	11·9	17·1	21	24·3	4·87	10·8	15·85	20	23·2	3·76	9·82	14·75	19	22·1	3·72	9·02	13·9	18	21·3	12
$P = \sqrt{6\sqrt{h}}\left(7·5 + \frac{V_l}{10}\right)$ ...	37·6	40·6	43	46·2	41·4	44·8	47·4	56	44·2	47·7	50·5	54·5	48·4	52·14	55·26	57·6	59·6	51·5	55·3	58·5	61·5	63·4	53·7	57·8	61·2	64	66·2	56·1	60	63·4	66	68·6	13
2 P ... ... =	75	81	86	92	83	90	95	112	88·4	95·4	101·0	109·0	96·8	104·28	110·52	115	119·2	103·0	110·6	117·0	125	126·8	107·4	115·6	122·4	128	132·4	112·2	120	126·8	132	137·2	14
Horse-power, CHP ... ... =	3·16				6·3				9·7				15·7					20·1				23					25					15
$B = \frac{550\ CHP}{P\ V_l}$	6·2	3	2·08	1·43	11·8	5·6	3·84	2·37	9·14	4·22	2·87	1·92	15·7	6·95	4·56	3½	2·98	22	9·26	5·97	4½	3·76	31·3	11·3	7·03	5¼	4·32	33	12·7	7·8	5⅞	4·7	16
$B = \frac{550\ CHP}{2\ P\ V_l}$	3·1	1·5	1·04	·715	5·9	2·8	1·92	1·185	18·28	8·44	5·74	3·84	31·4	13·90	9·12	7	5·96	44	18·52	11·94	9	7·52	62·6	22·6	14·06	10½	8·64	66	25·4	15·6	11½	9·4	17
$R_o = \sqrt{h}$ ... ... =	3·464				4·24				4·9				6					6·9				7·75					8·5					18

TABLE XVIII.—*Table of Belt Widths for Lathes using Carbon Steel. Cone of Four Steps Mounted on a Back Shaft and Geared to the Spindle at the Highest Speed of the latter by a Pair of Wheels of Ratio $R_o = \sqrt{h}$. Standard Diameter = 2 $(h - \sqrt{h})$. Two Countershaft Speeds. Effect of Altering Number of Back Gears upon the Lowest Speed and Width of the Belt.*

h ... ... =	12				18				24				36					48				60					72					1
N_g ... ... =	152				102				76·3				51					38·2				30·6					25·4					2
$\frac{N_g}{N_l}$ ... ... =	38				46				55				80·5					105				160					215					3
Number of back gears ... ... =	1	2	3	5	1	2	3	5	1	2	3	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	4
m ... ... =	2	3	4	6	2	3	4	6	2	3	4	6	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6	5
q ... ... =	4				4				4				4					4				4					4					6
$2q - 1$ ... ... =	7				7				7				7					7				7					7					7
s	16	24	32	48	16	24	32	48	16	24	32	48	16	24	32	40	48	16	24	32	40	48	16	24	33	40	48	16	24	32	40	48	8
Log. r	·1052	·0688	·051	·0336	·111	·0723	·0537	·0354	·116	·0757	·0562	·037	·127	·083	·0615	·049	·0405	·135	·088	·0653	·0518	·043	·147	·096	0·714	·0565	·047	·155	·1015	·0755	·06	·0496	9
r	1·275	1·171	1·125	1·08	1·291	1·181	1·132	1·085	1·306	1·191	1·139	1·089	1·340	1·211	1·152	1·119	1·097	1·365	1·225	1·162	1·127	1·104	1·403	1·247	1·179	1·139	1·114	1·429	1·263	1·190	1·148	1·121	10
r^{2q-1}	5·450	3·031	2·275	1·719	5·984	3·207	2·376	1·769	6·486	3·388	2·474	1·816	7·745	3·811	2·695	2·203	1·921	8·81	4·130	2·865	2·304	2	12·68	4·699	3·161	2·486	2·133	12·83	5·135	3·373	2·63	2·224	11
$V_l = \frac{48}{r^{2q-1}}$	8·8	15·81	21·1	27·9	8·2	15	20·2	27·2	7·41	14·15	19·4	26·4	6·2	12·6	17·8	21·8	25·0	5·45	11·62	16·75	20·8	24	3·78	10·25	15·2	19·3	22·5	3·74	9·33	14·2	18·2	21·6	12
$P = \sqrt{6\sqrt{h}}\left(7·5 + \frac{V_l}{10}\right)$	38·1	41·3	43·8	46·8	42	45·4	48	56·5	44·6	48·3	51	55	48·7	52·6	55·7	58	60	51·8	55·9	59·1	62	63·8	53·8	58·2	61·5	64·5	66·5	56·1	60	63·5	66·5	68·8	13
2 P ... ... =	76	82	87	93	84	91	96	113	89·2	96·6	102	110	97·4	105·2	111·4	116	120	103·6	111·8	118·2	124	127·6	107·6	116·4	123·0	129	133·0	112·2	120	127·0	133	137·6	14
Horse-power = CHP	3·16				6·3				9·7				15·7					20				23					25					15
$B = \frac{550\ CHP}{2\ P\ V_l}$	2⅝	1⅝	1	⅝	5	2½	1⅝	1¼	8	4	2⅝	2	14⅜	6½	4⅜	3·4	3	19¾	8½	5½	4·25	3½	31	10½	6¾	5·05	4¼	32⅝	12⅜	7⅝	5·7	4⅜	16
$B = \frac{550\ CHP}{P\ V_l}$	5¼	2⅜	2	1¼	10	5	3½	2¼	16·2	7·8	5·4	3·66	28·6	13·0	8·74	6·8	5·8	—	17·0	11·2	8·5	7·2	—	21·2	13·5	10	8·4	—	24·6	15·30	11·4	9·26	17
$R_o = \sqrt{h}$	3·464				4·24				4·9				6					6·9				7·75					8·5					18

rule. In ordinary course, with the proper or ordinary value of N_l (the lowest spindle speed) this would entail a high value of N_g / N_l; a correspondingly high value of r (the geometric ratio) for a given number of speeds; and a low value of V_l, that speed of the belt upon which its

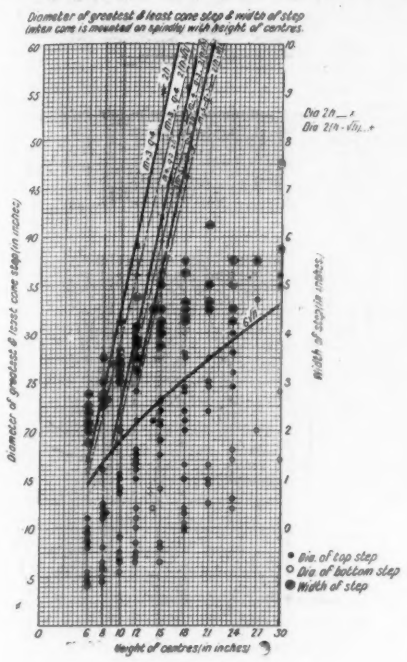

Diameter of greatest & least cone step & width of step (when cone is mounted on spindle) with height of centres.
Diameter of greatest & least cone step (in inches)
Width of steps (inches)
Height of centres (in inches)
Dia of top step
Dia of bottom step
Width of step

Fig. 23

width depends. In such cases the escape from the dilemma has been by the very simple and obvious trick of omitting a large number of speeds from the continuous range; so that there is a huge gap in the speed curve between those spindle speeds for which the cone drives it directly and those which are obtained through the back gears. An actual example is exhibited by Fig. 24, in which the spindle speeds are plotted in the ordinary way for this lathe. It was of 18in. centres, and had the cone

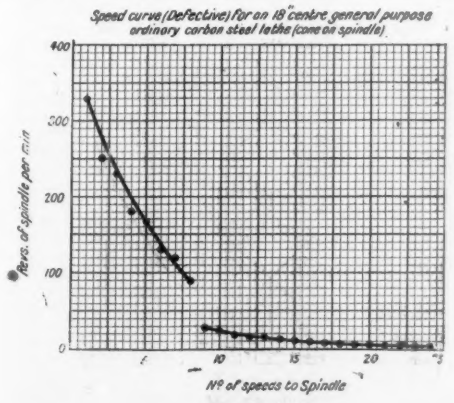

Speed curve (Defective) for an 18" centre general purpose ordinary carbon steel lathe (cone on spindle)
Revs. of spindle per min
No of speeds to Spindle

Fig. 24

mounted on the spindle. The proper value of N_g by our formula is 102 for this size, but by running the cone at a maximum speed of 330 the belt speed is much increased, and the width, instead of being 9in., was actually 4½in. This width enabled the lathe to take our standard cut at its proper speed; but only by leaving the gap in the speeds indicated in the figure.

The high spindle speeds shown in Fig. 24 serve no useful purpose either for turning, boring, or drilling, and the true speed range of such lathes is comprised within the limits of those for which it is driven by its back gears. As concerns polishing, for which some makers claim the speeds are necessary, we may again point out that the

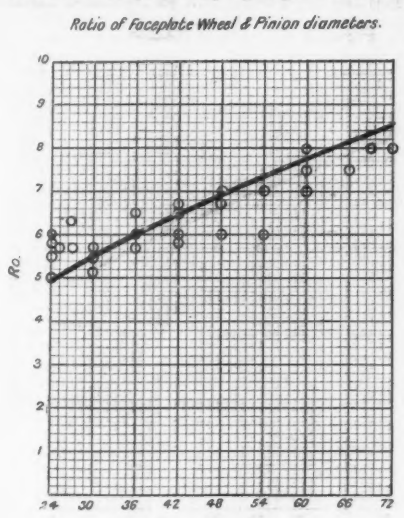


Fig. 25

rule we have adopted for N_g gives the respectable polishing speed of 120ft. per minute on work of any diameter larger than one quarter the height of the centres.

In conclusion, it may be said with reference to the belt widths shown in Fig. 23, that all the more eminent toolmakers mount their cones on a back shaft for lathes of over 18in. centres, and the propriety of this procedure is amply confirmed by the width indicated as necessary by the straight line curves of that figure calculated from our rules. We now pass on to the consideration of the next case.

Case II.—The cone is mounted upon a back shaft and drives the spindle for its highest speeds through a gear of ratio R_o. Provisionally we shall lay down the rule that $R_o = \sqrt{h}$, which gives ratios which are constructionally convenient. Fig. 24 gives the evidence from practice which justifies the acceptance of this value for the ratio of spur-wheel to pinion diameter through which the higher spindle speeds are obtained. The spindle speeds N_g and N_l being determined in the same way as before, the adoption of this rule for R_o obviously fixes the speed of the cone belt (as also the countershaft revolutions) when running upon any of its steps.

We have, in fact:—(as on page 464 *ante*)

$$R_o = \frac{n_g}{N_g}. \quad \text{Also } V_l = \frac{\pi A n_l}{12 \times 60}. \quad \text{And } \frac{n_l}{n_g} = \frac{1}{r^{2q-1}}.$$

$$\therefore V_l = \frac{\pi A n_g}{720\, r^{2q-1}} = \frac{\pi A R_o N_g}{720\, r^{2q-1}} = \frac{\pi A R_o \times 16 \times 12 \times 30}{720\, r^{2q-1} \times \pi h}$$

$$= \frac{48}{r^{2q-1}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (42)$$

From the values of V_l so calculated, and the assumed relation $A = 6\sqrt{h}$—which equally here is seen to be the practical rule for the diameter of the largest cone step (*vide* Fig. 26, full dots and curve)—Gehrckens' constants for the belt tension are obtained, and the belt widths are then easily found.

Throughout these belt calculations (as has been repeatedly pointed out), double the value of Gehrckens' effective tensions have been allowed, as being in better agreement with British practice.

The belt widths have been worked out on the above assumptions for lathes from $h = 12$in. to $h = 72$in., and the values have been entered in Tables XVII. and XVIII., and plotted in Fig. 26. The full line curves give the belt widths which are capable of pulling the standard

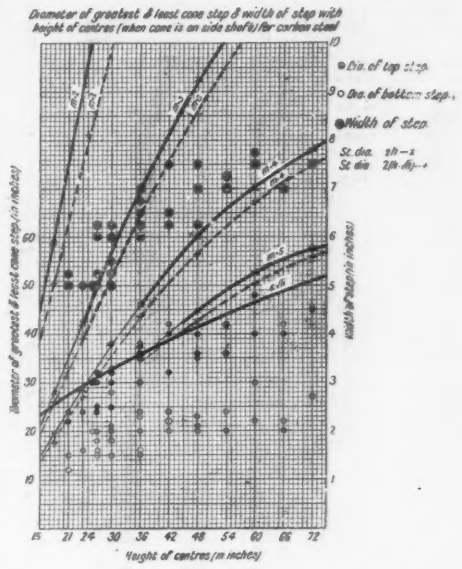

Diameter of greatest & least cone step & width of step with height of centres (when cone is on side shaft) for carbon steel
Dia. of top step
Dia. of bottom step
Width of step
Diameter of greatest & least cone step (in inches)
Width of steps (inches)
Height of centres (in inches)

Fig. 26

cut at its proper speed on a diameter equal to $2h$, the dotted curves on a diameter equal to $2(h - \sqrt{h})$. They are for two, three, and four back gears.

We see that the belt widths are no longer even approximately linear when plotted on the height of centres.

For lathes from about 26in. to 42in. height of centres the belt widths allowed in practice agree tolerably well with the values correctly calculated for two back gears.

From 42in. to 60in. centres the ordinary belt widths are too great, when compared with our calculated sizes for three back gears. At the same time it must be remembered that two or even four tools would sometimes be employed with such large lathes, and this may account for the apparent discrepancy. Each tool would, in that case, be taking a good deal less than the standard cut; but it is probable that the belt widths usually supplied are unequal to much more than the equivalent of one tool taking the standard area of cut at the proper speed unless the cutting speed is much reduced for two or more tools.

The effect of increasing the number of double back gears is very marked. In the case of a 54in. lathe, a 10in. belt is required when there are two back gears, a 6½in. when there are three, and only a 5in. when there are four. The following simple expressions for the belt widths hold within the specified limits. They are, of course, merely empirical; but may be of use in practice as giving close approximations to the correct sizes. They are of the linear type:—

$$B = K h \pm L.$$

Approximately correct formulæ for belt widths for lathes using carbon steel; cone on back shaft. Standard diameter = 2 h. 4 cone steps.

No. of back gears.	Formula.	Correct for lathes
One	$B = \frac{h}{2{\cdot}5} - 1{\cdot}5$	From 12in. to 21in. centres.
Two	$B = \frac{h}{5} - \frac{1}{2}$	From 15in. to 36in. centres.
Three	$B = \frac{h}{10} + 1$	From 36in. to 66in. centres.
Four	$B = \frac{h}{20} + 2$	From 42in. to 72in. centres.

In our next article the question of the compromise, for general purposes, of a lathe for the use of high speed steel for roughing out and of carbon steel for finishing, will be considered.

TABLE XVI.—*Belt Widths for Lathes using Carbon Steel, Cone on Spindle. Standard Diameter = 2 ($h - \sqrt{h}$). Only One Countershaft Speed.*

h =	6	9	12	15	18	21	24	1
N_g	305	201	152	122	102	87	76·3	2
$\frac{N_g}{N_l}$	29	34	38	41	46	49·2	55	3
Number of back gears	2	2	2	3	3	4	4	4
m	3	3	3	4	4	5	5	5
q	3	3	4	4	4	4	4	6
s	9	9	12	16	16	20	20	7
Log. r	·183	·1915	·143	·1075	·1168	·0832	·0916	8
r	1·524	1·554	1·390	1·280	1·290	1·228	1·235	9
$q - 1$	2	2	3	3	3	3	3	10
r^{q-1}	1·845	2·415	2·685	2·101	2·150	1·852	1·882	11
$V_l = \frac{48}{r^{q-1}\sqrt{h}}$	10·6	6·63	5·15	5·9	5·3	5·66	5·2	12
$P = \sqrt{6\sqrt{h}\left(7 + \frac{V_l}{14}\right)}$	30	32	—	—	—	—	—	13
$P = \sqrt{6\sqrt{h}\left(7{\cdot}5 + \frac{V}{10}\right)}$	—	—	31	36	38	39	41	14
2 P	60	61	68	72	76	78	82	15
Horse-power, CHP	·855	1·85	3·16	4·66	6·3	8	9·7	16
$B = \frac{550\ CHP}{2\ P\ V_l}$	·74	2·4	5	6	8·6	10	12·5	17

NEW VAUXHALL BRIDGE.

No. VI.*

HAVING brought up our description and illustration of the progress of the new metropolitan bridge over the Thames to the level assigned for the springing of the arches, we may now direct our attention to the general character and details of the steel work. As many of the exterior or face ribs are already in position, together with their interior neighbours, in all the spans, a very good idea may be obtained of the graceful outlines the finished structure, now rapidly approaching completion, will present. With the exception of the dolphins and floating booms, the whole of the temporary timber, staging, and falseworks have been removed from the waterway. It should be mentioned that all the houses, tenements, and other obstructions upon the Lambeth side, have been demolished and cleared away, and, it may be added, to the great advantage and improvement of the neighbourhood. The formation and concreting of the roadway, and the setting of the kerbstones, have been put in hand, so that the line of the south approach is distinctly demarcated. The masonry of the whole structure is now practically flush with the level of the floor-plates. Throughout the work, the granite blocks forming the stretchers in the facing are not less in length than twice the height of the course they belong to, and the headers have the base equal to the height. All beds are dressed back from the face for a minimum distance equal to the height of the course. Both abutments are faced above the level of the skewbacks with Bramley Fall stone,

* No. V. appeared in "THE ENGINEER," 4th November, 1904.

THE NEW VAUXHALL BRIDGE

(For description see page 64

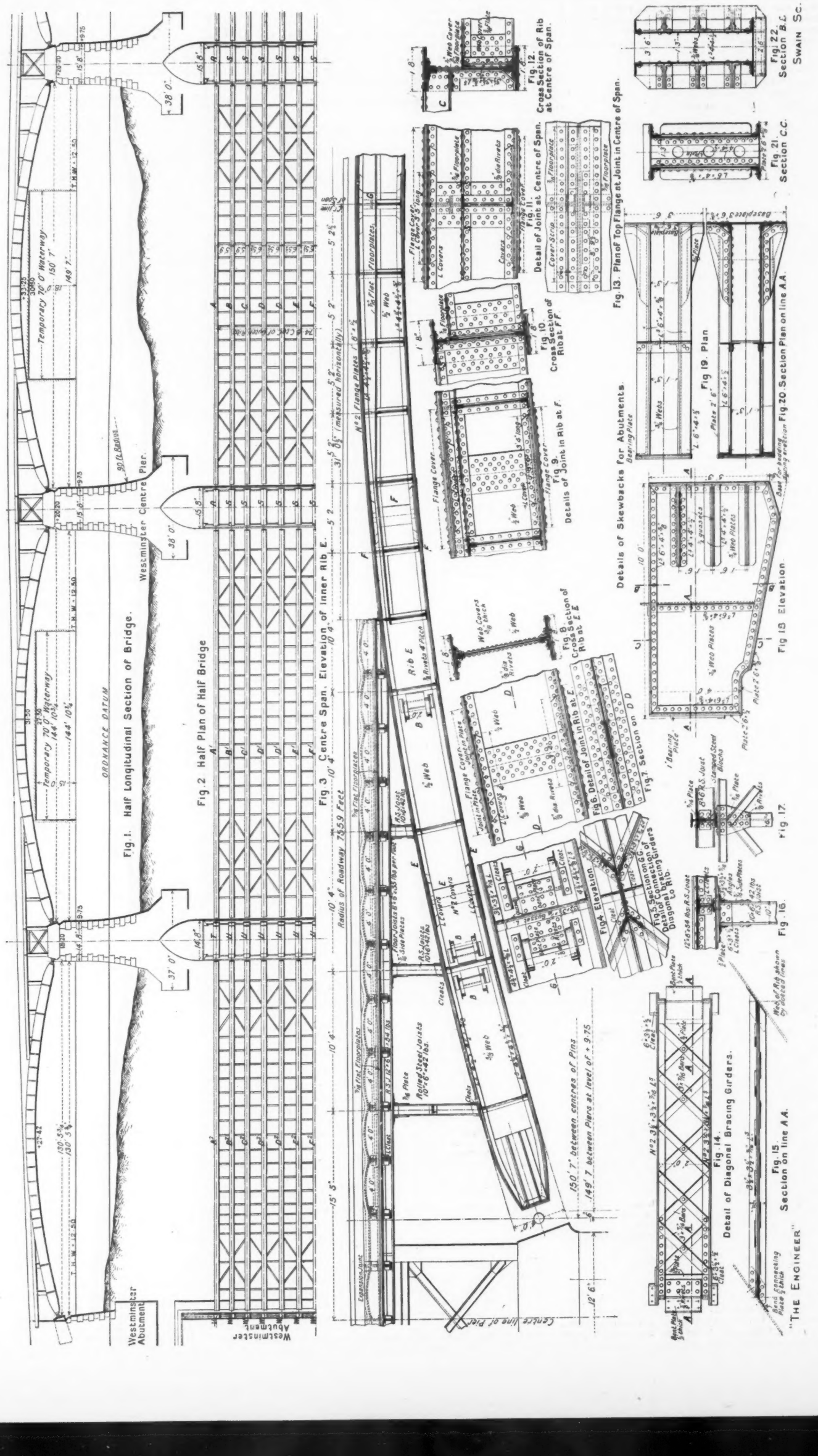


Fig. 1. Half Longitudinal Section of Bridge.
Fig. 2 Half Plan of Half Bridge
Fig. 3 Centre Span. Elevation of Inner Rib E.
Fig. 4 Elevation
Fig. 5 Section on G G
Fig. 6. Detail of Joint in Rib at E
Fig. 7 Section on D D
Fig. 8 Cross Section of Rib at E E
Fig. 9. Details of Joint in Rib at F.
Fig. 10 Cross Section of Rib at F F.
Fig. 11. Detail of Joint at Centre of Span.
Fig. 12. Cross Section of Rib at Centre of Span.
Fig. 13. Plan of Top Flange at Joint in Centre of Span.
Fig. 14. Detail of Diagonal Bracing Girders.
Fig. 15. Section on line A A.
Fig. 16.
Fig. 17.
Details of Skewbacks for Abutments.
Fig. 19. Plan
Fig. 20. Section Plan on line A A.
Fig. 21. Section C C.
Fig. 22. Section B L
Fig 18 Elevation
Westminster Abutment
Westminster Pier.
Temporary 70' 0" Waterway
ORDNANCE DATUM
Radius of Roadway 755.9 Feet
150' 7" between centres of Pins
149' 7" between Piers at level of + 9.75
Centre line of Pier
Expansion Joint
Bearing Plate
Base for bearing spring section
SWAIN Sc.

"THE ENGINEER"

and in the top course, 15in. in thickness, immediately under the roadway girders, the joints are so laid as not to come directly beneath the girder bed-plates. In the granite faces of the abutments slate dowels are inserted only in those courses where there is risk of damage by vessels colliding with them.

We may now pass on to the consideration of the steel work, of which material the superstructure is nearly entirely composed. A part of the steel work—the greater part in fact—will be riveted together *in situ*, but some portions of it have been built up outside the limits of the bridge works. A certain number of the ribs, which were floated up-stream and raised in to position, belong to this latter class, which will be further referred to.

The steel work in the superstructure of the bridge comprises five steel arches, represented in the half longitudinal section, Fig. 1. Each arch consists of thirteen plate arch ribs braced together, and pivoted at the abutments on steel skewbacks built into the masonry, so as to form an absolute *encastrement*. This arrangement is common to both the abutments, and is shown by the broken lines on that at Westminster, to the extreme left of the half section. Upon each pier there are double steel skewbacks extending right across it, and connecting the springing pivots of every pair of contiguous semi-arches. All the piers support a built-up trussed frame, which carries the roadway and receives the ends of the main stringers of the arches. Where they bear upon the vertical members of the steel frame expansion joints are introduced. Strong vertical stanchions, securely framed together, resting on the arch ribs, sustain the stringers, which in their turn hold up the transverse joists or small cross girders, upon which are placed the floor plates underlying the roadway.

The necessity of complying with those clauses of the Act of Parliament authorising the construction of the bridge, which govern the headway and waterway of the temporary under channels, renders it imperative that the ribs should be erected exactly to the levels specified. The widths and heights of the temporary waterways required for the central and the two symmetrically placed intermediate spans—Fig. 1—are 70ft. for the width of both the central and its neighbours, and a headway of 18ft. for the former and 15ft. for the pair nearer the river banks, measured from the level of Thames high water. The gradients of the bridge cause the springing level to be 2ft. lower on the shore side of each of the intermediate and shore spans than on the other. It follows from this difference of level that some small discrepancies arise in the two halves of these spans. These occur chiefly in the height of the stanchions carrying the main stringers over the ribs, and in the case of the shore spans, in the number of the stanchions. It should be stated that the gradients of the bridge are not the same on both sides of the centre line, and that the difference is allowed for in the thickness of the roadway, so that the general dimensions of the steel work of the two intermediate and two shore spans are identical.

At T.H.W. level the central arch has a waterway of 149ft. 7in., and a headway of 20ft. 9in. at the crown. The two intermediate spans are equal, and the waterways measure 144ft. 4½in., and headways 19ft. Waterways of 130ft. 5½in. and headways of 14ft. 11in. are the similar dimensions for the shore spans, which are also equal.

The half-plan of the bridge, with the flooring struts and parapets removed—Fig. 2—appears a little complicated, owing to the quantity of bracing between the ribs, which is of several types. In the centre and intermediate spans there are six diagonal bracing girders, of the same depth, but varying slightly in length, easily recognised. This number in the shore spans is reduced to four, to which the same remarks apply. These diagonal girders are all situated in the haunches of the respective arches. Wherever the decking is above the top flange of the ribs there are in all spans angle-braced transverse diaphragms, 3½in. by 3½in. by $\frac{7}{16}$in., between the ribs. At the centre of each arch, where the floor plates are below the upper flange of the ribs, all bracing girders are made of plates, and, in addition, the ribs are stiffened by the intermediate channel bars supporting the deck plates. The width between the centres of the outside or face ribs is 74ft. 8in., and the remaining ribs, with the exception of the two nearest to the face arches, are spaced 6ft. 5½in. apart. From the face rib to the one next it, and from the latter to its inside neighbour, the distance is 5ft. 9in. in both instances. In the different spans each rib is marked by the same letter, but distinguished by a small affix. Thus the face ribs marked A in the central span become A^1 and A^2 in the intermediate and side spans. At the same time, the ribs in the intermediate and shore spans, which are marked with the same letter, are not interchangeable, but are right and left-handed.

We may turn now from the general to the particular, and give our attention to the constructive details of the new bridge. The unimportant differences arising from the varying length of the central and side spans have been already passed in review, so they need not be further referred to. It will be sufficient, therefore, for our purpose to select one of the spans to illustrate the general design, and since the central is the largest, it is the best adapted to fulfil the part of an object lesson. Before bringing forward this part of the description, accompanied by the corresponding drawings, it will be advisable to furnish some particulars of the quality and character of the metal employed. The plates, angles, channel, tees, and other sections are of the best rolled mild steel, selected from approved brands. When tested by specimens of a uniform sectional area of at least a square inch, the steel of these sections was required to develop a tensile breaking strength of not less than 28 tons and not more than 32 tons per square inch. The elongation in any tested specimen was to be not less than 20 per cent. in an original length of 10in. All the steel had to bend cold, without cracking, through about 90 deg., to a curve whose diameter did not exceed twice the thickness of the sample.

An elevation of half of the inner rib E in Fig. 2 of the central span is shown in Fig. 3. The face ribs have a smaller depth than the others. They are 2ft. 9in. deep uniformly throughout, with flanges 1ft. 8in. in width. At the springings, the inner ribs are made deeper, 4ft. as against 3ft. 6in. over all, and only vary in the arrangement of the bracing, the gusset pieces, and mode of connection. In all of them the flanges consist of plates ½in. in thickness, except in the case of the central ribs, in which the thickness is increased to ⅝in. The half elevation—Fig. 3—may be said to consist of two parts, the one in which the decking is above the upper flanges of the ribs, and the other in which it is below it. In the former, the decking which carries the concrete of the roadway consists generally of flat and curved plates, all $\frac{7}{16}$in. in thickness, resting upon rolled steel joists, 8in. by 6in., at 35 lb. to the foot run, lettered A on the elevation. These are 4ft. apart, and laid transversely over or between the main stringers, except for a distance of 30ft. from the centre of the bridge, where the level of the decking is below the top of the arch ribs. Along this part the decking is supported alternately on the plate bracing between the ribs, and on channel steels—lettered C in Fig. 12—12in. by 3½in. by 3½in. at 30 lb. per foot, placed back to back and secured to gussets on the ribs. The ribs are of the built-up plate girder pattern, and for the central arch comprise symmetrical upper and lower flanges consisting of a pair of plates 1ft. 8in. by ⅝in., and a couple of angles 3½in. by 4½in. by ⅝in., uniting them with the web by rivets ⅞in. in diameter. Near the ends of the arches the thickness of the web is increased to ⅝in. At the point where the decking cuts the upper flange of the rib, the lower is struck with a radius of 238ft. 1½in., and the upper with one of 251ft. 11in. Figs. 4 and 5 are an elevation and section on the line G G, of the details of the connection of the diagonal bracing girders and the ribs mentioned in the description of Fig. 2, marked B on the main rib, Fig. 3. The flanges of the girders, upper and lower, consist of two angles 3½in. by 3½in. by $\frac{7}{16}$in., and are secured to the web of the rib by cleats 6in. by 3½in. by ½in. A gusset angle is fixed over the whole depth of the main rib, and a bent plate ½in. thick and 1ft. 5in. deep, clinches a troublesome obtuse angled joint.

In Figs. 6 and 7 are examples of a flange and a web joint, and a few remarks may be made respecting the general conditions pertaining to this very important part of the steel work. All joints are close and flush, and the holes drilled to template. The edges of all flange and gusset plates, and the ends of all plates, angles, and other sections, are planed true and square, and the several thicknesses of flange plates are planed at the same time at one operation. Upon the efficiency of the riveting depends the whole value of the joint, from the initial punching or drilling of the holes, to the final snapping of the head. In the present instance, after the holes are drilled full and clean to accurately-marked templates, the arrises round them are removed. Whenever feasible, the several thicknesses of flange plates are clamped together, and the holes drilled right through the series. The plates are afterwards separated and cleaned off before riveting. All rivets are of the best mild steel, specially manufactured for the purpose, and having a tensile strength from 24 to 28 tons per square inch. Both rivet heads are specified to be full-sized, concentric with the hole, and the riveted-up head well snapped. No rivets are nearer together than 2⅜in. from centre to centre. Preference is given to hydraulic or pneumatic "squeezer" riveters, but where it is impossible to use these, pneumatic pistol riveters may be substituted. The joints in both of the double plates of the upper and lower flanges of the main rib—Figs. 6, 7, and 8—have each a single cover 1ft. 8in. × ⅝in. and 4ft. 8in. in length, and the angle steels have double covers 4in. × 4in. × ⅝in. A plate 1ft. 5in. wide × ⅝in. thick forms the wrapper for the web joint, one on each side of it. Where the floor plates, $\frac{7}{16}$in. thick, which are carried upon angle stringers 3½in. × 3½in. × $\frac{7}{16}$in., pass below the upper flange of the main ribs, the mode of arranging the joints in the flanges and web is similar to that already described, with the exception that the dimensions of the flange covers are altered. The thickness of both the flange and web covers is unaltered, and the angle wrappers remain as before. Vertical stiffening girders built up of a $\frac{7}{16}$in. plate, and a pair of angles 3½in. × 3½in. × $\frac{7}{16}$in., are shown in Figs. 9 and 10, and the stringers are lettered S on all the figures on which they occur. A detail of the joint, a plan of the upper flange at that point, and a cross section of the main rib, all at the centre of the span, are given in Figs. 11, 12, and 13. Except in unavoidable knees and joggles, there is scarcely any bending or cranking of the steel work. Filling pieces are introduced instead; this plan brings the work up flush and straight, makes a better job of it, and imparts a neater and more finished appearance to it. A better idea of the manner in which the diagonal bracing girders are connected with the web of the main ribs will be obtained by referring to Figs. 14 and 15, which are almost self-explanatory. Between the pairs of the longitudinal angles forming the upper and lower flanges of the lattice bracing girders is placed a bar, 3½in. by ½in., which acts as a continuous washer to the rivets passing through the flange angles and the tie-bars of the web.

Proceeding with the elevation, Fig. 3, a little further explanation is necessary. The figure is taken along the tramway line, where flat floor plates are used. These are supported at intervals of 4ft. upon rolled steel floor joists, 8in. by 6in., at 35 lb. to the foot, marked A in Fig. 3, which are framed in between each pair of the stringers of the main ribs and fastened to them by angle cleats, 4in. by 4in. by ½in. The ordinary roadway is carried upon curved floor plates, resting upon the floor joists A, which in this instance are fixed on the upper flanges of the stringers. This arrangement is shown by the dotted lines in the elevation. In the same vertical plane as the arch ribs, the main roadway joists or longitudinal stringers of rolled steel joists 12in. by 6in. by 54 lb., are situated. Those over the outside ribs, measure 18in. by 7in. by 75 lb., and are securely riveted to the upper plates of the stanchions or spandril pillars, similar to all the others. Owing to the necessity for providing for the tramway conduits, and also for mains and pipes, the level of the decking is not the same along the whole of the cross section of the bridge. Immediately beneath the longitudinal stringers which they support, are the vertical stanchions. They are steel joists, 10in. by 6in., by 42 lb., and are bedded upon the upper flanges of the main ribs, 10ft. 4in. apart from centre to centre, and secured to them by four cleats 6in. by 4½in. by ½in. This distance is reduced to 5ft. 2in. where the stanchions rest upon the outside or face ribs. A plate 2ft. 1in. in length by 1ft. 1in. in width, and ½in. thick on the top of the spandril pillars connects them, by angles 6in. by 3in. by ½in., to the main stringers. This attachment appears in Figs. 16 and 17, which are elevations at right angles to one another, and explain very clearly the manner in which the floor joists are fitted in between the longitudinal stringers, and the bracing of angles 3½in. by 3½in. by $\frac{7}{16}$in. in the transverse plane of the bridge. The floor joists, 8in. by 6in., are provided with stamped steel bearing blocks, where they cross the lower flanges of the main stringers. A few alterations have taken place in the constructive details of the steelwork since the letting of the contract. One has reference to the ends of the main arch ribs, which, in Fig. 3, retain the original curved contour, but are now changed to a square termination, with a 4ft. plate, 1in. thick, instead of one of 2ft. 2in., of the same thickness.

There are two classes of skewbacks, the one belonging to the abutments and the other to the piers, and they are chiefly distinguished from each other by the former being single and the latter double. At both the abutments the whole thirteen skewbacks are built up alike, according to the design in Figs. 18—22. They closely resemble box girders with the upper horizontal plate removed, as in section—Fig. 22—and are composed of a couple of webs, each ⅝in. in thickness, and stiffened round the periphery and about half-way across the elevation—Fig. 18—by angles 6in. × 4in. × ⅝in., with a lower base plate 30in. wide and ½in. thick. At the upper end the bearing plate for the cast steel hinges forms the pivot, and at the lower end, where the skewback rests on the masonry, the bearing plate is 3ft. 6in. in width and ⅝in. in thickness. This plate is further strengthened by gussets of ½in. plate and 4in. × 4in. × ½in. angle steels. The rearward end of the skewback is also stiffened by three pairs of angles, and gusset plates between them, riveted together, as seen in the elevation.

In setting the skewbacks, after the abutments are brought up to the proper levels, they are fixed in position by temporary wedges, and the concrete is brought up round them in successive layers not exceeding 18in. in thickness. Before proceeding with each separate layer, the joints between the concrete and the plates of the skewbacks are fully grouted up, and the operation continued until the skewbacks are completely *encastrés* in the concrete. Old rails are built into the abutments behind the skewbacks to increase their bearing area. The bedding and setting of the skewbacks, and filling them with concrete, requires to be very carefully executed, so that they shall form an integral part of the abutments, and be exactly true in position. A diaphragm plate ½in. thick, riveted to the webs by angles 4in. by 4in. by ½in., is shown in the cross section—Fig. 21. All the rivets in the skewbacks are ⅞in. in diameter, but the pitch varies. In the rib of the angles measuring 6in. the rivets have a double pitch of 6in., and in the 4in. rib the pitch is 4in. single.

The difficulty of fixing in position an arched rib is considerably greater than a straight girder having a horizontal lower flange. A greater nicety of adjustment, more accurate and precise measurements, and much "small steering" are required in dealing with the rib type. The case of the girder is one of simple superimposition, and it is a matter of comparatively no consequence whether the bearings rest by first intention equally or unequally upon the supports. As a matter of fact, the ends of girders are generally deposited upon baulks of timber, acting as temporary bed-plates. This plan was adopted in the raising, by the flotation process, of the large unsightly polygonally-shaped main trusses of the temporary bridge lower down the stream.* The ribs of the north and south shore spans were riveted up on platforms erected over the piling, and the work was easily accomplished, as no navigation is allowed beneath. It was not possible to rivet up the ribs at the workshops of the contractor, Mr. Charles Wall, at Grays, inasmuch as when mounted on the pontoon they would be unable to pass under the river bridges. They were accordingly delivered in sections on board the pontoon moored near the adjoining temporary bridge, put together on deck and afterwards floated to their destination higher up the stream.

It will be seen, on referring to the Westminster abutment on the extreme left of Fig. 1, that the forged steel turned pins are inserted in the semicircular sockets of a pair of hinges. These, an upper and a lower, are of cast steel, and very nearly identical. The first step towards fixing the ribs was permanently to attach the lower hinge to the skewback, insert the pin, turn the other hinge over it, and temporarily bolt in to its fellow beneath. Thus the parts to be brought into contact comprised the back of the upper hinge and the 1in. bearing plate riveted over the end of the ribs. It is evident, bearing in mind that a similar operation was being carried out at the other springing of the ribs—for the fixing was contemporaneous for the three—that a small space or some clearance was necessary, in the first instance, between the two surfaces. This was effected by building the crown of the rib ½in. higher and jacking it up on the pontoon, so as slightly to shorten the length of the chord line. When the ribs had been lowered to the position shown in the engraving—Fig. 23—they were secured by temporary joggles, and as the pontoon descended with the falling tide, they adjusted themselves to their permanent bearings, were bolted to them, and the whole operation successfully accomplished. Fig. 24 is a view of the three ribs belonging to the central span, after the removal of the pontoon. For the photographs of Figs. 23 and 24 we are indebted to the courtesy of Mr. Trail, engineer to Mr. Charles Wall, contractor for the works. It is not intended to employ the flotation method for any additional ribs. The remainder will all be built out upon staging fixed to their neighbours already erected. We must reserve for our next article a description of the plan adopted.

*THE ENGINEER, May, 13th 1898.

PROGRESS OF WARSHIPS AND MACHINERY BUILDING IN ENGLAND.

IN an article under this heading, which appeared in our issue of the 8th of last July, we noted that the "mammoth" battleship idea of our naval authorities had been put aside for the time, but that two smaller, yet powerful ships, known as the Lord Nelson class, had been ordered. Consequent, however, on the lessons taught in the present war, more particularly in the late great naval battle of the Sea of Japan, where large, swift warships, armed with long-range, heavy guns of great striking power won the day, it has now been decided by the British Admiralty to revert to the idea of the "big" battleship, and the only ship of the kind included in this year's building programme—which we give later on in this article—and which will be laid down in the Royal Dockyard at Portsmouth next October, will be the largest and most powerful warship—both in offence and defence—that the world has ever seen.

This vessel, designed by Mr. Watts, which is to be named the Dreadnought, will, it is reported, be constructed in the record time of sixteen months from the laying of the first keel plate to being put into commission. Her displacement will be about 18,000 tons, and she will be so heavily armed that her striking power will be equal to that of any two battleships now afloat. She will mount ten 12-inch guns, throwing 850 lb. shells, with a muzzle velocity of 2500ft. to 2800ft. a second. She will necessarily be a vessel of great beam and moderate draught in order to give her a stable platform for her guns, and enable her, if required, to pass through the Suez Canal. She is to be propelled by turbine engines of 23,000 indicated horse-

power to give her a steaming speed of 21 knots an hour, which for a vessel of her displacement will be a most praiseworthy and notable achievement. Steam will probably be supplied to her engines by Babcock and Wilcox water-tube boilers.

Of the work completed and in hand in the Royal Dockyards, we have first to note that since the date of our previous report—January 20th ult.—two battleships have been launched from these dockyards, viz., the Africa, built at Chatham, on the 20th May, and the Hibernia, built at Devonport, on the 6th of the present month; particulars and dimensions of both these vessels have been given in previous articles.

The launch of the Hibernia having released a number of hands, the construction of the armoured cruiser Minotaur—building in the same dockyard—the typical ship of her class, the particulars of which we gave in our last article, will be rapidly forwarded. The only other vessels building in the Royal shipyards are the two armoured cruisers the Warrior and the Defence at Pembroke, and the first-class cruiser Shannon at Chatham.

The vessels in the "completing" stage are the battleships New Zealand and Britannia at Portsmouth, the Africa at Chatham, and Hibernia at Devonport, together with the cruisers Devonshire and Duke of Edinburgh at Chatham and Pembroke respectively. The date of the completion of the second-class cruiser Encounter, which was commenced on the 28th of January, 1901, at Devonport Dockyard, is quite problematical, as she has lately made two, if not more, attempts at running her necessary steam trials, but has had to return to harbour on each occasion with heated bearings. The real cause of the heating being as yet undiscovered, the whole of the principal parts of the engines are now being taken to pieces for thorough examination.

As to the new constructions for the Navy proposed to be commenced during the financial year 1905-6, they comprise 1 battleship, 4 armoured cruisers, 5 ocean-going destroyers, 1 experimental ditto, 12 coastal destroyers, and 11 submarines; the one battleship is the Dreadnought previously mentioned.

The absence of any reference to construction in our old yard at Sheerness will be noticed. This is occasioned by the Government decision to have no more warships built in the yard, but to reserve it solely as a "repair" yard for torpedo-boat destroyers. Since the beginning of this year the yard has been greatly improved, new workshops provided with up-to-date plant, and especially new machine tools and appliances in the engineering department, having been installed.

A rumour having got abroad that all new ships building, or to be built, for the Navy are to be fitted with tanks for the storage of liquid or oil fuel, it is well to state that the utilisation of oil as a boiler fuel has not as yet passed the experimental stage, and therefore a passed successfully through her trips, and is now being few only of the ships now building are being adapted for oil storage. The conversion, however, of any nearly completed ship—of the King Edward VII. class—into a carrier of oil fuel will, it is to be feared, necessitate many alterations and add greatly to her cost.

Turning now to the private shipyards and engine works in England in which warships and their machinery are constructed, we find that in the past six months the following progress has been made in the yards named:—

At Elswick, the third-class cruiser Amethyst has, since her very successful trials, been handed over to the Admiralty. The first-class cruiser Hampshire has also finished. The Fleet scout Adventure is now preparing for her official runs, and the sister ship Attentive is almost ready for trial. The first-class armoured cruiser Achilles was launched on the 17th inst., and will shortly receive her machinery. The first-class battleship Kashima, built at Elswick for the Imperial Japanese Navy, has also been put into the water, and has now all her machinery on board.

As the particulars of dimensions, engine power, armament, &c., of all the above-mentioned vessels, built at the Elswick Works, have been given in previous articles in THE ENGINEER, it is unnecessary to repeat them.

There is again little to report in reference to the fitting of turbine machinery to warships by the Parsons Marine Steam Turbine Company, of Wallsend-on-Tyne, since the completion of the cruiser Amethyst for the British Navy. The firm has, however, received an order for a set of turbine machinery for one of the coastal destroyers, building to the order of the British Admiralty, by Messrs. Thornycroft and Co., of Chiswick.

At Palmer's Shipbuilding Company's works at Jarrow-on-Tyne, during the past six months, there have been launched the two destroyers Wear and Swale, and after successful speed trials the destroyers Ure and Rother have been delivered, and will be followed by the Wear, whose official runs are also completed; while preparations are being made for the trials of the Swale.

The keel of the first-class battleship Lord Nelson, the typical ship of her class, was laid at the Jarrow shipyard on the 18th of May last, and since then rapid progress has been made. This is the ship that at the date of our last report was considered to be so powerful that no vessel then building would have a chance of victory if pitted against her. This, since the decision to build the Dreadnought, is no longer the case.

Passing on from the Tyne to the Thames—there being now no warship work on the Humber—we find that during the past six months great progress has been made towards the completion for her steam and other trials of the first-class cruiser Black Prince, built by the Thames Ironworks Company, at Blackwall, for the British Navy. All six of her 9·2in. guns with their shields are fitted in place, together with the amunition, shell, and other hoists, armour on her sides, bulkheads, conning towers, &c., and the ports are all ready to receive the ten 6in. guns. The under-water torpedo tubes are nearly complete, and the cabin fittings, store rooms, magazines, &c., are waiting their final coat of paint. The pumping, draining, ventilating, and water-tight door arrangements are also practically complete. The matter connected with the provision in the ship of an oil fuel service for the boilers, which the Admiralty has only lately decided to fit, is in a rather backward state. The ship's masts and funnels are all in place, as well as the topside fittings, and there is little doubt that the vessel will be on her trials in September, and ready for handing over to the Government before the end of the year.

Since our last report, when the fitting of the machinery of the armoured cruiser Devonshire by this firm was nearly finished, the vessel has completed her steam trials and been handed over to the Admiralty. These trials were specially satisfactory, the ship having attained on the full power test a speed on the mile of 22·97 knots, and on the eight hours' run 23·19 knots, during the best hour of the eight the speed being practically 24 knots. There has also been completed at the Greenwich works the cylindrical boilers for the battleship Britannia, now completing at Portsmouth.

At Yarrow and Co.'s works, at Poplar, of the two destroyers, the Gala and Garry, in hand for the British Government at the time of our last report, the Garry has undergone her full speed official trials, the results of which were of special interest, as the shape of the after part of the vessel differs materially from that generally adopted, resembling somewhat the design now common for racing motor boats in that the breadth at the stern is nearly the same as amidships, the counter considerably overhanging the propellers and protecting them from damage, and giving at the same time more space for cabin accommodation aft and coal-carrying capacity than in the ordinary destroyer-shaped hull. That there is less submerged resistance was proved by the trial of the vessel, when a speed of 26¼ knots was attained; other vessels of the same class varying from 25¼ to 26. Both the Gala and Garry will be shortly handed over to the Government by the builders.

The trials of the first-class torpedo boat Kaiman and the destroyer Huszar, built at the Poplar yard for the Austro-Hungarian Government, have also been very successful, the former having attained a speed of over 26 knots, carrying a load of 55 tons; and the latter a speed of 28½ knots with a load of 100 tons.

The nineteen Yarrow water-tube boilers for the armoured cruiser Warrior, building at Pembroke, are ready for delivery; while twenty-four for the cruiser Shannon, and one for the Naval College at Dartmouth, are in hand at the Poplar works. Yarrow and Co. have also lately received an order from the Government for two coastal destroyers, the Mayfly and the Moth, each to be 172ft. long by 18ft. beam, fitted with turbine machinery.

At the Chiswick shipyard and engine works of J. I. Thornycroft and Co., the two destroyers Chelmer and Colne have successfully passed all their official trials, and are now completing for sea at the company's works at Southampton. The destroyer Magne, building for the Swedish Government, described in our last report, is receiving her propelling machinery, and will shortly be ready for trial. A service pinnace is also being fitted for the British Government with a reversible petroleum motor of 75 brake horse-power. Messrs. Thornycroft are also laying down five twin-screw coastal destroyers of a new type, which are to have a speed of 26 knots, burn oil, and fitted with Parson's turbine-propelling engines driving three shafts.

At Cammell, Laird and Co.'s, shipyard and engine works at Birkenhead, the cruiser Diamond, of the Topaze class, which had, at the date of our last report, completed her official trials, was shortly afterwards taken over by the Admiralty and put in commission. The two fleet scouts, the Pathfinder and Patrol, have been completed, and having both successfully passed through their official trials, are now being brought forward for delivery; the first-mentioned will probably be handed over in a week's time. Of the three 25½-knot destroyers, the Liffey, Moy, and Ouse, built for the Government, the two first have successfully completed their trials; the Liffey has been delivered at Devonport, the Moy will go into the Fleet Reserve in a day or two, and the Ouse is about ready to commence her trials.

SIMPLON TUNNEL MEDAL.

THE successful piercing of the Simplon has been commemorated by the striking of a medal, of which we reproduce the obverse and reverse below. On one side appears a figure of Mercury, and a locomotive emerging from the tunnel, with the inscription "Aux Collaborateurs et Ouvriérs du Percement

du Simplon"; and on the other is represented the meeting of the workmen when the last barrier was broken down, with the words "Souvenir de la Rencontre des Galeries, Fevr., 1905." One of these medals, struck in bronze, has been kindly sent to us by Messrs. the Baugesellschaft für den Simplon Tunnel, Brandt, Brandau & Cie., Winterthur.

THE ROYAL AGRICULTURAL SHOW.

THE sixty-sixth annual exhibition of the Royal Agricultural Society opened at Park Royal, Acton, on Tuesday last, under extremely favourable climatic conditions. It is hoped that a continuance of fine weather and the presence of members of the Royal Family may bring a larger number of visitors than has been the case in recent years. In some respects the prospects can be said to be more favourable than was the case last year. Not only is the prize money larger, but the total entries exceed those of the last six Shows. In fact, the display of live stock has probably been rarely more representative. Nearly £8000 is offered in prizes, but beyond the Society's silver medals, no inducement, in the way of monetary reward, is held out to exhibitors of implements. This reason, however, is probably not sufficient to account for the regrettable falling off in the number of exhibitors in the machinery section, which is still on a fairly large scale. It contains 6590ft. run of ordinary shedding, and 1750ft. of machinery in motion. There are also interesting sections devoted to agricultural education, British forestry, meteorology, and dairying. If only a small percentage of the public residing in and around the great metropolis could be induced to understand that such an exhibition is of interest to others than those whose livelihoods are dependent on the land, we feel sure that, as far as the gate money side is concerned, its permanence would be assured. Whether or not the London public is of the kind required to command the attendance of implement exhibitors is a doubtful matter.

Although covering a smaller area than hitherto, the implement section may be said to be fairly representative. The complaint which we have had to make on so many recent occasions respecting the dearth of new appliances, around which much of the interest in this report is concentrated, is more applicable than ever. In turning over the pages of the implement catalogue, we find that there are over fifty miscellaneous devices entered for the Society's medals as "New Implements for Agricultural and Estate Purposes," but many of these—if new—can lay claim to very slender grounds upon which to deserve the coveted award. Some, however, are worthy of notice here. There is shown, for instance, by Messrs. Barford and Perkins, of Peterborough, a self-propelling roller of undoubted utility for large estates and cricket grounds. As will be observed from the illustrations on page 645, the machine is a combination of a water-ballast roller with a petrol motor. The hind roller is 36in. in diameter by 42in. long. The engine is a Simms two-cylinder vertical petrol motor capable of developing 8 horse-power. It has the Simms Bosch magneto ignition and mechancical valves. The cylinder is water-cooled, a sufficient body of water being carried in the circulating tank to enable the cooling to be efficiently done without the aid of a radiator. The tank is placed over the hind roller, so that its weight is in a useful position and its height renders a pump unnecessary, the circulation being automatic. A friction clutch on the motor spindle allows the engine to run free for starting, and when running can be instantly released at will. The total weight of the roller with tank empty, but with everything in working order, is 2 tons 15 cwt., of which 1 ton 19 cwt. is on the back roll and 16 cwt. on the front. With the hind roller filled with water the total weight is 3 tons 4 cwt. 1 qr., all the additional weight, of course, being at the back. Two speeds, either forward or backward, are arranged for, viz., one mile and three miles an hour, the change being conveniently made from the driver's seat. By varying the number of revolutions made by the engine, intermediate speeds can be obtained. Reversing is effected by means of three machine-cut bevel wheels combined with a claw clutch moved by a lever within easy reach of the driver. The reduction of speed from the motor to the roller spindle is obtained in three steps, the first two being by means of spur gearing, the higher-speeded gears having machine-cut teeth, and the third step by the chain connected to a wheel on the roller cylinder. The steering is effected through the hand wheel in front of the driver, which is connected by chain gearing to the steering head. The bridge spanning the front rollers allows a considerable oscillation of these rollers when passing over stones or other obstructions without affecting the level of the main frame. All levers are within easy reach of the driver. To render the machine of double utility a pulley can be provided on the first motion shaft, from which any light machinery can be driven. In the line drawing 1 is the second motion shaft; 2, the second shaft spur wheel with 144 teeth; 3, a mitre wheel with 23 teeth; 4, the third shaft mitre wheel of 23 teeth; 5, the third motion shaft; 6, the reverse clutch; 7, fork and rod; 8, loose collar; 9, quick-speed pinion, 25 teeth; 10, slow-speed pinion with 11 teeth; 11, speed clutch; 12, speed-clutch fork; 13, reverse bell crank; 14, speed bell crank; 15, reverse connecting-rod; 16, speed connecting-rod; 17, reverse lever; 18, speed lever; 19, fourth motion shaft; 20, spur wheel with 49 teeth; 21, spur wheel, 63 teeth; 22, small chain wheel; 25, brake wheel.

Another new implement is a vertical water-tube boiler, shown by Messrs. F. C. Southwell and Co., 75, Southwark-street, London. This boiler may be described as of a modified de Dion type. It is fired through the top, has a large amount of heating surface crowded into a small space by means of a number of short, inclined tubes, and the tubes can be reached for cleaning without removing the outer shell or the boiler mountings. Messrs. Thomas Glover and Co., Limited, Queen Victoria-street, show several sizes of the Gothic oil engine, which works on the two-cycle system similar to the gas engine described in our Supplement last week. The speed of the oil engine may be regulated within certain limits by altering the position of the lamp or burner with relation to the firing tube. This is done by a hand screw and gear wheels. Although not entered as a new implement, the next machine in rotation which calls for remark is the self-binding harvester shown and manufactured by Messrs.

Richard Hornsby and Sons, Limited, Grantham. This machine will compare favourably for lightness of draught, and soundness of construction, with the harvesting machines for which some American makers have deservedly acquired such high reputations, while its price is such that foreign competition should be defied. It speaks volumes for the development which has taken place in workshop, and particularly foundry, practice in this country that such an appliance can be placed in the hands of the farmer for about half the price of an average draught-horse. Messrs. J. L. Larkworthy and Co., of Worcester, show Lee's patent revolving harrow. The machine is circular in plan, being carried on a vertical shaft, and is caused to revolve by the draught of the horses. Its speed of rotation is regulated by a balance weight carried on a horizontal arm mounted pivotally on the upright shaft. Mr. T. M. Jarmain, of Haseley Ironworks, Oxon, shows a swath turner of light draught and capable of passing through a 7ft. gateway. The improvements consist in placing the left-hand or "near" side flier in front of the axle, and the right-hand or "off" side flier to the rear of the axle, instead of having both the fliers behind. By this arrangement the road wheels are brought closer together and the fliers nearer to the axle. The frame of the machine is extended forward, and the fore part is carried by a swivel wheel, the front flier being suspended from the frame. A lever is provided for adjusting the height of the flier, and for raising when necessary to clear obstacles. The swivel wheel enables this flier to ride over ridges and furrows, in the same way as the rear flier, which is carried by a trailing wheel as hitherto.

A motor lawn mower and roller with cutters 42in. wide is shown by Messrs. Thomas Green and Son, Limited, of Leeds. The engine has two vertical cylinders capable of giving 8 horse-power. It is provided with two systems of ignition, namely, magneto and high-tension, with accumulators and trembler coil. The machine has one speed only, the speed of the engine being reduced to a suitable degree by epicyclic gear before the motion is transmitted to the travelling gear. The front portion of the machine is hinged, and free to move, which enables the cutter to adjust itself to any irregularities on the ground. The cutter can be thrown out of gear or raised from the ground by hand levers. The collecting box is fitted with patent delivery apparatus, operated by driver without stopping the mower.

The Knowlson combined plough and potato planter, shown by Messrs. John Searby and Co., Limited, Rotherham, marks a new departure in the method of planting potatoes. The planter consists of an arrangement of spoons, driven by a chain from the axle of the front wheel, and, passing upwards through the hopper filled with potatoes, each spoon takes one, carries it through the tube, and deposits it on the ground or manure just behind the driving wheel, and can by a change of chain wheels be made to plant the potatoes at any suitable distance apart. The front or driving wheel runs in the centre of the row bottom, and makes a mark for the potatoes to drop in. The plough arrangement follows immediately after, and is double breasted and adjustable. A lever in front of the operator, and within easy reach, is connected with the wheels to take the machine out of work at the ends of the row, and is easy of manipulation. The potatoes are claimed to be evenly planted down the centre of the row, and are in less danger of being cut off by the scruffler when the time comes for that operation. Two horses and one man are necessary to work the combined machine.

Messrs. H. P. Saunderson and Co., Limited, Bedford, show among the new implements a self-propelling tractor of somewhat novel design, and intended for farm and estate purposes, such as for carrying or hauling, or it may be used as a stationary power plant. It has three wheels, the two leading wheels being the drivers, and derives power from a vertical two-cylinder internal combustion engine, designed to work with either petroleum, spirit, or heavier oils. When necessary the rear wheel can be detached so that the frame of the machine can be yoked to a plough or other vehicle. The machine shown weighs about 35 cwt., and the engine is said to be capable of developing 30 horse-power. Power is transmitted from the engine through a clutch to a gear box situated over the front axle, and three forward or reverse speeds are provided. The implement seems to be very substantially constructed, and should be powerful enough for any kind of work on a farm. The Ivel Agricultural Motors, Limited, show a tractor of the type which is familiar to our readers, but having an 18 horse-power internal combustion engine, adapted to use either petroleum, spirit, or paraffin. With this object a special carburetter has been designed, so that after the engine has been running for a few minutes on spirit the vaporiser has required sufficient heat to start the engine running on the heavier oil, or the use of petrol may be abandoned by applying a lamp to the carburetter. This tractor weighs, we are informed, 28 cwt., and has two speeds.

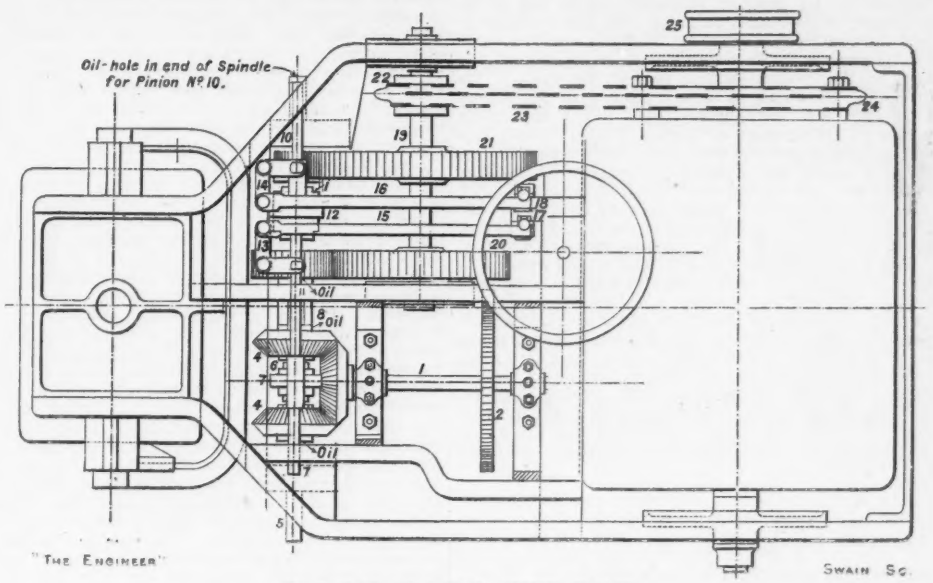


Fig. 1—PLAN OF PETROL MOTOR ROLLER

The exhibits of motor wagons are fewer than in recent years. Mann's Patent Steam Cart and Wagon Company, Leeds, has on view a steam tipping cart and lurry, and a new type of road wheel for winter use. This has wood blocks held in place round the rim of the wheel by adjustable steel side-plates, which can be adjusted inwards as the wood blocks become worn. The St. Pancras Ironwork Company, Limited, shows the 5-ton steam wagon which was recently described in these pages. Messrs. William Allchin, Limited, Northampton, show a steam wagon with a locomotive type of boiler with side firing. It has a compound engine, and drives by chains on to the rear road wheels. The engine and gearing are entirely enclosed—a good feature, if convenience for access to the working parts is not sacrificed. Fodens, Limited, Sandbach, are also represented by a steam wagon, whose features are already well known.

Amongst the exhibitors of traction engines and road locomotives may be mentioned Messrs. John Fowler and Co. (Leeds), Limited; Marshall, Sons, and Co., Limited, Gainsborough; Richard Garrett and Sons, Limited, Leicester; Aveling and Porter, Limited, Rochester; Clayton and Shuttleworth, Limited, Lincoln; Ransomes, Sims, and Jefferies, Limited; William Allchin, Limited; Chas. Burrell and Sons, Thetford; Wallis and Steevens, Limited, Basingstoke; J. and H. McLaren, Leeds; William Foster and Co., Lincoln; Ruston, Proctor, and Co., Limited. The most noteworthy feature amongst the exhibits of these firms is the tendency to build lighter engines, which come within the tare limit of the Motor Car Act. In this departure Garretts, Aveling and Porter, Clayton and Shuttleworth, and Wallis and Steevens are all identifying themselves.

Gwynnes, Limited, 81, Cannon-street, have a working installation of centrifugal pumps, including an oil motor 6in. centrifugal pump, and dynamo combined. The engine is of the vertical type, worked by ordinary petroleum, and the pump will deliver 650 gallons per minute to a height of 20ft., while the dynamo has an output of 3·6 kilowatts. The plant has no gearing or belting, and is particularly suitable for irrigation works. On the stand of this firm are also exhibited for the first time a number of specimens of castings and forgings of Ruebel metal, which possesses remarkable qualities judging from the results of tests made by eminent persons in this country. It is a mixture of common brass with a 6 per cent. alloy of a secret compound, and may be cast or forged with facility.

The display of oil engines is up to the usual standard, but beyond those already mentioned no new features of importance are to be noted.

We regret to say that the attendance of the public has so far shown no sign of improvement. The Show closes to-day, Friday, a day earlier than in previous years.

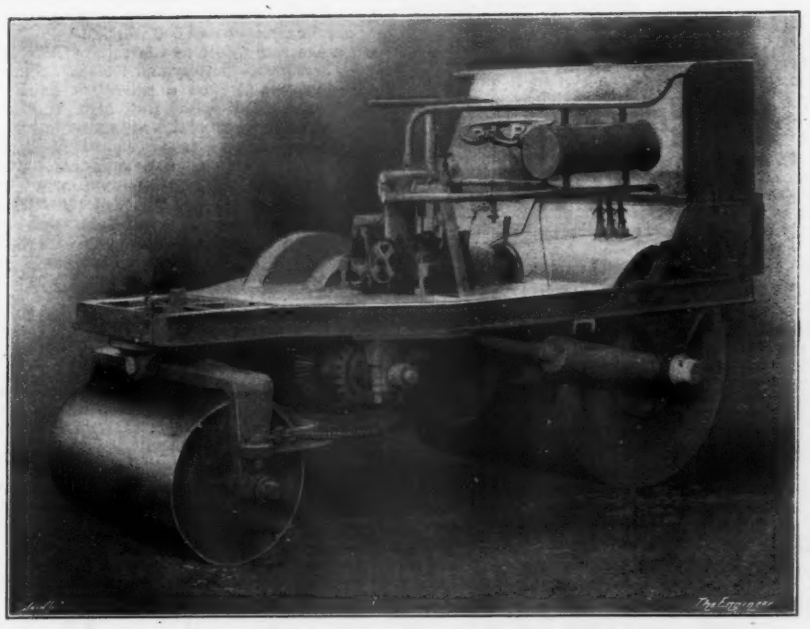


Fig. 2—BARFORD AND PERKINS' MOTOR ROLLER

OBITUARY.

THOMAS LISTER.

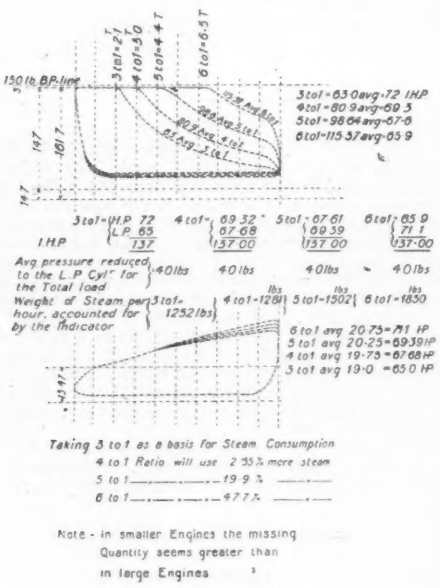
THE death of Mr. Thomas Lister occurred at his house, Morton, Gainsborough, on the 18th inst. Mr. Lister, who was both an architect and an engineer, was associated with the Stephensons, as well as with George Hudson, known as the "Railroad King" in the early days of railway development.

Born at Wath, near Doncaster, in 1809, the son of a stonemason, he was apprenticed to a carpenter, but afterwards gave up that craft to go to his brother, an architect at Rotherham. Here he was set to make tracings of plans of bridges in connection with the construction of the Grand Junction Railway, now the London and North-Western. In 1837 he assisted in the construction of the Sheffield and Rotherham Railway, and turned the first sod half-way between the two towns. Afterwards Mr. Lister prepared an estimate for the line from Blisworth to Oundle for Stephenson, who next set him to work on the branch line from Blackburn to Preston. On the completion of this undertaking Mr. Lister in 1841 superintended the construction of that portion of the then Manchester, Sheffield, and Lincolnshire Railway between Bole, Notts, and New Holland, on the banks of the Humber. The principal portions of this work were the Kirton Lindsey tunnel, built on an incline and cut through a rock full of springs, and the railway bridge over the river Trent, where quicksand difficulties were met with and overcome.

At a later period Mr. Lister was engaged by Mr. John Fowler to cut a canal across the South Beveland in Holland. He was engineer to the Gainsborough Urban Authorities until 1866, when he engaged in the shipbuilding business with Mr. Trenery, carrying out in the meantime private works for Lord Middleton, Sir T. Beckett, and Lord Hawke, father of the present captain of the Yorkshire County Cricket Eleven. Mr. Lister erected the Sheepbridge Ironworks in 1857, built in 1864 the Gainsborough Waterworks, and in 1867 became architect and surveyor to Messrs. Marshall and Co., of Gainsborough, during which he undertook many other important works. Mr. Lister retained his position with Messrs. Marshall until a few years ago. He was connected with the building of the first "skew" bridge notable in connection with all Stephenson's contracts, and his experiences of Yorkshire engineering works were exceptionally interesting. The later years of his life were spent in the Gainsborough district, and shortly before his death, which occurred at the advanced age of 96, he was in a very feeble state. He leaves a daugher and a son, the latter having been for many years the Russian representative of Messrs. Marshall, of Gainsborough.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE fourth paper taken at the Liège meeting on Tuesday was that by Mr. A. L. Mellanby, entitled "An Investigation to determine the effects of steam jacketing upon the efficiency of a Horizontal Compound Steam Engine." This paper was not read, but the author explained what were the various points made in it. However, we commence to reprint it on page 657. It was followed by an excellent discussion, which had to be adjourned to Wednesday morning. Mr. Saxon wished to know in what precise sense Mr. Mellanby used the words "mean pressure." That depended, as he understood the facts, on the relation existing between the sizes of the cylinders. It would be a very good thing for engine builders if Mr. Mellanby was right and a high mean pressure gave the most economical results, because then smaller engines could be used which would represent less invested capital for a stated power. But he held that to draw any such general conclusion from results obtained with one small engine would be very dangerous. He then proceeded to criticise some of the numerous figures given by the author. He had tried ratios of 4 to 1 up to 6 to 1, but he believed that the best results were got in Lancashire practice with a ratio of 4 to 1 in compound engines and 150 lb. pressure. Makers were asked to guarantee a consumption of 12 lb. of water or thereabouts per indicated horse-power. But Mr. Mellanby got a best result of 16·93 lb., which might be good for a very small experimental engine, but was quite useless in the present day for big mill engines. As to the missing quantity, no general rule could be laid down; it varied in every engine. Mr. Saxon then chalked on the board the diagram, which we give herewith and which explains itself.


150 lb BP line
3 to 1 = 2 T
4 to 1 = 3·0
5 to 1 = 4 T
6 to 1 = 6·5 T
3 tot = 63 0 avg = 72 IHP
4 tot = 80 9 avg = 69 3
5 tot = 98 64 avg = 67·6
6 tot = 115 37 avg = 65 9
IHP
3 tot = IHP 72 L.P. 65 137
4 tot = 69 32 67 68 137 00
5 tot = 67 61 69 39 137 00
6 tot = 65 9 71 1 137·00
Avg pressure reduced to the L.P Cyl^r for the Total load
40 lbs
Weight of Steam per hour, accounted for by the Indicator
3 tot = 1252 lbs
4 tot = 1281 lbs
5 tot = 1502 lbs
6 tot = 1850 lbs
6 to 1 avg 20·73 = 71 HP
5 to 1 avg 20·23 = 69·39 HP
4 to 1 avg 19·73 = 67·68 HP
3 to 1 avg 19·0 = 65·0 HP
Taking 3 to 1 as a basis for Steam Consumption
4 to 1 Ratio will use 2·55 % more steam
5 to 1 —— 19·9 % ——
6 to 1 —— 47·7 % ——
Note - in smaller Engines the missing Quantity seems greater than in large Engines

Mr. Vaughan Pendred said that those who followed with care the trend of recent opinion would see that the theory of initial condensation seemed to be going out of favour. The missing quantity had become leakage instead of condensation. What, if this were true, became of the elaborate mathematical disquisitions which had been given to the world on cylinder condensation, showing precisely how to calculate its amount? For himself he believed still in initial condensation, and not in leakage, in well-made engines. He wished to ask whether any inquiry had been made into the influence of compression on the efficiency of jackets. There was some reason to believe that the higher the compression the greater was the gain obtained by jacketing, but there were not data enough yet available to enable a sound opinion to be expressed.

Mr. Henry Davey said that the performance of steam engines was full of anomalies. He, in effect, endorsed Mr. Saxon's arguments. Results obtained with a bad engine were likely to be very misleading. It appeared from this paper that the best results were obtained with only eight expansions, and a terminal pressure in the low-pressure cylinder of 22 lb.; whereas, in daily practice, the best results were got with terminal pressures as low as 6 lb. It would be found in practice that the better an engine was the less good could the jacket do; until, in very perfect engines, it ceased to be of any use at all.

Mr. Mark Robinson said that though a high mean pressure did not give the most economical consumption per indicated horse-power, it might very well be the most economical referred to first cost and brake horse-power. He knew of one very successful firm who used a mean pressure as high as 40 lb. He did not believe in leaky valves, unless as a result of bad design and neglect. He concluded by referring to Captain Sankey's experiments, which have already been described in our columns.

The meeting then rose, and a large number of members took lunch at the Lisansky Restaurant in the Exhibition grounds, and afterwards a very large party visited the Cockerill Works at Seraing, just outside Liège, and on their way back smaller parties visited other places of interest.

It was as long ago as 1817 that John Cockerill, the son of an English emigrant, was given, by the King of Holland, the Castle of Seraing and its dependencies with permission to construct a works on the site. He made such good use of his opportunity that very soon the Cockerill machines—which embodied the best practice as carried out in England, where alone at that time, mechanical construction had become important—had made a name for themselves. In 1824 a blast furnace was erected, and was blown by steam engines. In 1835 the firm constructed its first locomotive and rolled its first rails. In 1863 the first Bessemer converters to be erected on the Continent were put into operation at Seraing—in fact, it is said, and with a great deal of truth, that the company has always been the first to import on to the Continent any English invention of value. The founder, John Cockerill, died in 1840. At that time, owing to a series of unsuccessful undertakings, the company was in a gravely compromised position, and work was stopped for a time. However, in 1842 a Société Anonyme was formed with Gustave Pastor, Cockerill's nephew, at its head. About this time there were some 3000 to 4000 workmen employed, now the numbers vary between 9000 and 10,000, and the average yearly wage paid to each man is just over £50. It would be impossible with the space at our disposal to give even a remote idea of the undertakings of this important company. It has everything at its disposal which it requires in its work. It has mines, both metal and coal, the latter within the precincts of the works. Some of the coal it produces is so good that it pays to sell it and purchase a cheaper quality for manufacturing purposes. It has a shipbuilding establishment at Hoboken, near Antwerp. Its manufactures include steam and gas engines, ships and boats, bridges, ordnance, locomotives, armour plate, projectiles, steam hammers, dredgers, cranes—in fact, its business deals with practically every branch of engineering. The manufacture of steel, iron and coke, is extensively carried on. It was one of the leaders, if not indeed the actual pioneer, in the use of large gas engines working with blast furnace gas. The company does not only confine its attention to actual manufacturing. The École Industriale de Seraing was founded largely owing to the initiative of the Société Cockerill. An Association of old students of this school is subsidised. A naval school has been created at Hoboken. There is a hospital and an orphanage, and five doctors are employed to give medical attendance. These visit the works and the workmen's dwellings daily. There is—an unusual thing for the Liège district—a number of workmen's dwellings, some of which are models of their kind; and workmen's messes are provided in each department. The company also assists pecuniarily a number of independent institutions, including the Workmen's Co-operative and Mutual Assistance Societies, schools, institutes, literary, musical, gymnastic, and fencing societies, dispensaries, &c.

With this brief reference to the Cockerill undertakings we pass on to notice a new generating station for electric power which has just been opened on the banks of the Meuse, and it will, we think, be of interest to devote a little space to a short description of the principal features of the installation.

The visitors were received by M. R. Boulvin, the managing director. The station belongs to a company called the Société d'Electricité du Pays de Liège. M. Boulvin, who is an engineer living at Brussels, is designing at the present time other generating stations at Brussels, Ostende, Charleroi, and St Denis, near Paris. The latter is the largest, and will have steam turbines of 4000 to 5000 kilowatt capacity, and boilers with a total heating surface of 100,000 square feet. He was good enough to take the visitors all over the Liège station and to give detailed information about the plant. The station is quite new, and hardly complete, current only having been supplied for some fourteen days. The company was formed to generate current and to sell in bulk to large consumers. It furnishes part of the current used by the Acieries d'Angleur, which are close at hand, and also high-tension current to the Commune de Seraing, and to the Société Oxydrique, while it also provides continuous current for the tramway service upon certain lines in Liège and its vicinity.

The building is a fine brick structure, with lofty chimney, which forms a very conspicuous object, as it is surrounded by a wrought iron water reservoir, a vertical section of which is shown in Fig. 1. The plan is circular.

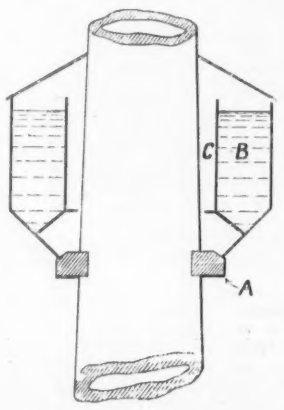


Fig. 1

A represents a course of dressed stone to support the tank, B is the water, and C a space between the chimney stack and tank to permit of repairs or painting. This tank holds 150 cubic metres of water, and is fixed at a height of 25 m. above the ground, while the height of the chimney itself is 65 m. The design appears to us to offer considerable advantages, as it saves the cost of an expensive water tower.

The steam generating plant is placed upon the ground floor, and at present consists of seven boilers, of a special type, made by the firm of Jacques Piedbœuf, of Jupille, Liège. This type is shown in Fig. 2, and is very largely used in Germany. The lower part is precisely like a short Lancashire boiler, except that the end plates are dished

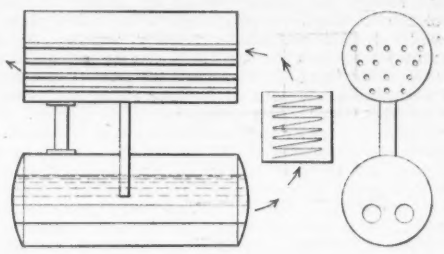


Fig. 2

considerably. The gases pass out of the furnace tubes into a chamber, in which is fixed a superheater, then through flame tubes inside the top cylinder, thence to a Green's economiser of 360 tubes, and from there to the chimney. Each boiler will evaporate about 3000 litres of water per hour, and the steam is produced at a pressure of 12 atmospheres—180 lb. per square inch—and superheated to 300 deg. Cent. The coal used is of two kinds, one of which we should call "smudge" and the other "slack," both known as "charbon menu." These two kinds are mixed and fired by hand. We were informed that no mechanical stokers are used in Belgium, as the coal is said to be unsuitable for their adoption. Steam is supplied to the electric generating plant, which is fixed upon the first floor level. The plant at present consists of two steam turbine sets, each set comprising a turbine, coupled direct upon the same shaft to three dynamos. The one next the turbine is an alternator, developing 1500 to 1800 kilowatts, with three-phase current, at 6600 volts, and 50 cycles per second; the next, a direct-current machine, producing 850 kilowatts, with 600 volts, for tramway work; and the third a direct-current exciter for both the former machines. The turbines are of the Parsons type, and were built by the Cockerill Works at Seraing, while the dynamos are by Messrs. Brown, Boveri and Co., of Baden, Switzerland, and the plant runs at 1500 revolutions per minute.

On the ground level, below the engine-room floor, are installed the condensing plant, the air pumps, feed pumps, &c. Each air pump and each feed pump is driven by its own electric motor. The circulating pumps for the condensing plant are also driven in the same way, and were built by Sulzer Brothers, of Winterthur. Condensing water is taken direct from the river Meuse and returned to it. After the steam has been condensed, the water of condensation is led to two large water meters, built by Benno Schild, of Hersfeld, Germany. Each apparatus consists of two large measuring tanks, into which the water pours alternatively by means of an automatic rocking lever device and special shoots. The engineer thinks this meter far preferable to any of the types used so largely in England. The water is measured at a temperature of 45 deg. Cent., and then flows to the hot well. There is a large Tudor secondary battery installed, but not yet filled with acid. It has a capacity of 800 ampères per hour for ten hours, at 600 volts.

Upon the same floor as the turbine sets are installed the boosters for the battery and for the negative line of the tramway, and upon a gallery is fixed the large switchboard, fitted with the high and low-tension apparatus. The whole of this apparatus was supplied and fixed by the Ateliers de Constructions Electriques de Charleroi. At the time of our visit only one turbine set was running; the other set is used on alternate days. The actual readings of the gauges at about 4 p.m. was as follows:—Vacuum, 74 cm.; pressure of steam, 11 atmospheres; pressure of oil in the forced lubricating system, 1·2 atmospheres; temperature of the steam, 210 deg. Cent., but this is only temporary, and will be 300 deg. Cent. in a few days.

In the evening the members were entertained at a banquet in the Salle de la Renommée by the Society of Liège Engineers.

The proceedings were opened on Wednesday, the 21st June, by the President, at 10 a.m., and the discussion upon Mr. Mellanby's paper was resumed. Professor H. Hubert, speaking in French, said that the author had dealt at considerable length with the question of the value of the steam jacket on the outside of the cylinder, but if the protection from cooling was to be complete the piston-rod also should be jacketed, as otherwise a considerable quantity of heat was carried out of the cylinder at each outgoing stroke. The first practical application of such a method was made by M. Beer, and the engine was exhibited at the Brussels Exhibition. This system has

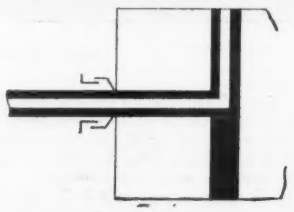


Fig. 3

since been simplified by M. George Duchesne. The speaker then made some sketches upon the blackboard to illustrate his remarks. The diagram, Fig. 3, shows a piston with a body hollow in the upper half and solid in the lower half, and the piston-rod is hollow. The solid part of the piston was designed to allow the water of condensation to be cleared out more easily.

M. Francois, of the Société Cockerill, has also brought

out a system with two piston bodies upon the same piston-rod, the space between the two bodies being filled with steam at a high temperature; this is seen in the sketch annexed, Fig. 4, which shows the steam-jacketed cylinder with the

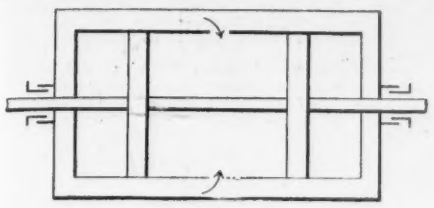


Fig. 4

two piston bodies and the port arranged so that the steam from the jacket can fill the space between the two bodies. The engine thus arranged presented a strange appearance. When it was used condensing and with a steam pressure of 10 atmospheres, 3887 calories were used per horse-power hour. Messrs. Cockerill decided to build a compound engine, and this used 5·098 kilos. of steam per horse-power hour, which is equal to 3367 calories, without any superheating whatever, and this the speaker considered much better than the Allis engine. As the clearance spaces cause great loss it is important to reduce the exposed surface as much as possible, and in the case described the total surface was only three times the cylinder area, which he thought very good. The output of the engine was 189 horse-power; M. Françoiz is about to publish his results. He also pointed out that M. Ducheane, of Brussels, had pushed his experiments further, and measured the temperature of the walls of the cylinder at each tenth of the piston stroke. He could not give full details of the apparatus, but they would be found in the *Revue Universelle des Mines*, and they consisted of a thermo-electric thermometer and galvanometer. The speaker showed three diagrams. Each had a black and a red curve, the former referring to the temperature of the steam and the latter to the walls of the cylinder. These diagrams had been produced by plotting the results obtained, and they showed clearly that the steam in the cylinder was superheated at the end of the stroke, and no water could possibly remain. One of the diagrams referred to a cylinder without steam jacket. With a steam jacket the walls, of course, remain far hotter, and at the end of the admission the steam is rapidly superheated, and it is impossible to have water in the cylinder. The speaker also considered that the jackets should be kept as hot as possible. He had made tests in which the jacket was supplied with steam at 12 atmospheres—180 lb.—supplied by an independent boiler, while the steam supplied to the cylinder itself was only of 6 atmospheres—90 lb. The steam in both cases was used direct from the boilers, and was therefore saturated. This system was in use with an engine by Bonjour at the Liège Exhibition, and the François engine was also there at the Cockerill stand, but was not working. His general conclusion was that the steam in the cylinder, even without a jacket, becomes superheated after the end of the admission, but even more, of course, with a jacket than without.

M. Georges Duchesne then also spoke in French and exhibited three diagrams to illustrate his experiments. The first showed the results obtained by taking the temperatures of the cylinder walls and of the steam in the cylinder at every tenth part of the stroke, the cylinder being without a jacket; the second showed similar observations made with a steam jacket heated by steam of the same pressure as that admitted to the cylinder; and the third showed the results obtained when the pressure in the jacket was considerably higher than the pressure in the cylinder. He proposed to substitute for the usual term of the equation $k\,(\theta - t)$ another term $k\,(\theta - t) + k\,\epsilon\,(\theta - t)$ to give more exact results, ϵ being a constant depending upon the special engine under consideration.

M. Mathot then referred to certain tests which had been made at Magdeburg with steam engines of various types. The first was of a semi-portable engine; the boiler had 130 square feet of heating surface, the proportion of grate area to heating surface being 1 : 33; the ashes were 6 per cent., and the temperature of the superheated steam 592 deg. Fah., with 430 deg. Fah. in the chimney. The engine developed 25 horse-power at 200 revolutions per minute. On a nine hours test 24·93 brake horse-power was obtained, and an efficiency of 90 per cent. The total coal used was 2·2 lb. per brake horse-power hour, and 2·01 lb. per indicated horse-power hour, with a steam pressure of 95·5 lb. He also cited the case of a compound condensing engine with 160 square feet heating surface, and a ratio of 1 : 35. The ashes in this case were 7·68 per cent., the feed water 97 deg. Fah., the average steam pressure 172·6 lb. per square inch, the temperature 657 deg. Fah. in the high-pressure cylinder and 361 deg. Fah. in the low-pressure cylinder. The evaporation per pound of coal used was 8·56 lb of water, and the engine developed 38·2 horse-power. The coal used was 1·3 lb. per brake horse-power hour, and the steam used was 10·8 lb. per brake horse-power hour, the admission was 30 per cent. to 35 per cent. These figures might all be compared with those given by the author.

Mr. Mellanby, the author, then replied, and said he did not work the engine described with a view to get the best economical effect, but he had obtained a series of tests at low speeds, and these would show the action of the steam jacket. When the engine was run at its normal speed of 90 revolutions per minute, the consumption of steam was about 3 lb. less per brake horse-power hour than the figures quoted in the paper. In his opinion the relative changes in the temperature of the cylinder walls and of the steam in the cylinder must be known before it was possible to improve the efficiency of the engine. His own experimental engine was provided with piston jacketing also, but in the experiments quoted he did not use it.

The next paper taken was "The Growth of Large Gas Engines on the Continent," by Mr. Rodolphe Mathot, of Brussels. This paper, which extended to fifty-five pages, and which we shall deal with in a future issue, was read by the author in abstract, and a discussion then followed.

Mr. Crossley, Manchester, thanked the author for his paper, and said that the development of large gas engines had been great on the Continent, but chiefly for use with blast furnace gas. In England a great deal had been done with bituminous coal gas producers; possibly British makers were awaiting the results obtained from the work done in Germany. He did not exactly agree with the author that the hit-and-miss system of governing was doomed, as he thought it would still be used for the smaller engines, and he suggested that even for the larger engines it was useful in combination with an automatic cut off gear. The automatic cut-off should be used down to, say, half power, and the hit-and-miss gear below that power. Either the combustion must be limited, or the mixture must be limited, and the pressure kept high. Hit-and-miss governing is good for low pressures, and none of the new German ways of governing were of use without high-pressure. Tube ignition was still used, but for town gas and small engines only. The tube was invented by Mr. Atkinson, and it enabled the pressure to be raised to 60 lb., instead of 45 lb., which was the highest pressure with the old slide. He thought it a great mistake to give up the use of cylinder liners, as this would lead to costly repairs. The arrangement shown in Fig. 8 of the author's paper was never much used in England. Körting had introduced a piece of metal to prevent the incoming gas going direct to the exhaust pipe. There appeared to be no agreed standard arrangement for the position of the valves among the German engineers. Could not the author give a standard design? No scavenging was now used with pressures of 200 lb. He knew of no German equilibrated valves except those shown in Fig. 41, and these were bad, as a double-seated valve could not be kept tight. Fig. 44 was an arrangement which must lead to a breakdown. If any tar were present it would prevent the slide moving, and his firm gave up the use of the slide long ago. On page 42 the Nuremberg firm was said to instruct their customers that the valves and cylinders should be dismantled and examined monthly. This was obviously a clear proof of difficulties.

M. Mathot rose to say that this must be an error in translation or in his original French, as the Körting engine was run for seven months without cleaning.

Mr. Crossley, continuing, said he was afraid continental engineers followed steam practice too closely and put unnecessary work into their engines. They must have had many cylinder heads broken if it is necessary to use steel instead of cast iron.

The statement on page 30 of the paper that the Otto Deutz firm has made 70,000 engines must be the combined product of themselves and a number of licensees; he was sure that his own firm had made more than the Deutz people, and Messrs. Crossley's product up to date was only 54,000 engines. Speaking of the use of producers the speaker said, on page 54 of the paper were given interesting tests of thermal efficiency upon dry coal, but he would like to know what was meant by dry coal. The buyer purchased coal as it came from the pit, and therefore containing moisture. A 16 brake horse-power gas engine built by his own firm got an efficiency of 25 per cent. of the whole of the calories in the coal delivered, and he should expect 25·5 per cent. on an engine as large as that described by the author. They now had no difficulty in getting rid of tar, and gas companies would have to be very careful, and reduce their prices for gas if they were successfully to compete with producer gas.

Mr. John Fielding, Gloucester, said that Mr. Crossley had put the English position so fully that he could add nothing, except that with regard to governing M. Mathot would remember that out of all the engines in the Brussels Exhibition the English engine was the only one which ran without a hitch throughout the whole period.

M. Frederick Kraft, Seraing, said that tube ignition and hit-and-miss governing were now abandoned by his firm for large engines; they used only variable admission. Electricians were their best customers except for blowing engines, and a large fly-wheel was necessary for electrical work to keep the speed constant. Variable cut-offs were made on different systems; the first idea was to follow steam practice and to admit a diminished quantity of gas, but this varied the composition of the charge. Then, again, variable compression was of disadvantage at low loads, as it was impossible to balance the inertia of the moving parts. In constant compression the idea was to take in always the same quantity of air and vary the quantity of gas, but they would get miss-fires at low loads. Some makers take in air and at some part of the stroke let in the gas according to the position of the governor and thus get constant compression. He thought it necessary to have constant compression at all loads for electric lighting. For blowing engines which must run at variable speeds, his firm has given up high compression as at slow speed it would make it difficult to get over the dead centres.

M. Rodolphe Mathot, Brussels, then replied, and said that the hit-and-miss system was invented in England, and it was perhaps natural that Englishmen should wish to retain its use. About two years ago he became consulting engineer to the firm of Bollinckx, and advised its use, but was obliged to give it up. Hit-and-miss governing was not good for suction plants, as when explosions were missed the generator was cooled below its proper temperature. His present paper dealt solely with large gas engines; he had already written three papers for the Congress of the Mining Engineers, and these should also be referred to in order to obtain other records of tests. The inlet and exhaust valves shown in the figures in the same axial line were not both driven by the same cam. Messrs. Körting used separate cams. Valve setting was not neglected in Germany, and scavenging was effected by opening the air valve before the exhaust closed. He had made 350 tests of engines in the last fifteen years, and all the results would be found in the papers he had cited. Probably the figures 70,000 for the production of the Otto Deutz firm included the engines made by their licensees. Dry coal meant coal as it comes out of the pit, but the explanation of his statements in the paper was that if the coal had been wetted considerably during transit it was dried before the tests, to bring it back to its natural condition. As to producers, he had been called to test a good many new patterns in France for use with bituminous coal, but had found three out of four a failure; probably Messrs. Crossley would eventually succeed with their producers on the suction principle.

On Thursday, the 22nd June, a party consisting of about one hundred members and ladies, took the train at 9.11 a.m. at Liège for Spa, and on arrival there they were met by the carriages provided for the visit to the reservoir dam at La Gileppe. La Gileppe was reached about 1 p.m., and after lunch had been taken at a hotel close to the

THE RESERVOIR DAM AT LA GILEPPE

reservoir, the party was joined by Messrs. Detienne and Leclercq, and by the engineer to the town of Verviers. In the absence of the President, Mr. Martin, his place was taken by Mr. Edward B. Ellington, a vice-president, who said a few words to the party, collected upon the top of the dam, and took the opportunity of introducing the Belgian engineers. After this M. Detienne described, with the aid of certain plans, the general scope of the work, drawing the attention of the members to the cross-section of the dam, and comparing it with the cross-section of a dam at Alicante, in Spain; and also with the section of a French dam, which clearly showed that the Gileppe dam was a far stronger section than either of the others. Owing to very heavy storms in the previous week and to a landslip of a good deal of clayey soil, the water in the reservoir at the time of the visit was very muddy, but it was explained that this was a very unusual occurrence, the water at ordinary times being clear. Attention was drawn to the almost vertical disposition of the strata on both sides of the valley of the Gileppe River, which has enabled the engineers to carry the structure of the dam into recesses prepared in the sides of the valley and to make the joints perfectly water-tight. The reservoir serves the town of Verviers with water for drinking purposes as well as for use in cloth factories. For washing wool it is of the greatest importance that the water should be free from lime, and the situation of the dam was chosen, as it is at some distance from the calcareous area. The dam itself consists of a large embankment 90 yards long and 72 yards thick at the base, and 256 yards long and 16 yards thick at the top. The height of the parapet is 154ft., and the normal level of the reservoir is 148ft., its area being 200 acres, containing 2700 million gallons. It was constructed between the years 1867 and 1878 by Messrs. Braive, Caillet and Co., from plans drawn up by M. Bidaut. M. Leclercq then gave a description of the method of taking off the water from the reservoir, as the designer would not permit of any holes being made through the dam itself. The water is, therefore, taken off by two subterranean galleries, which lie in the shape of a horse-shoe round the dam. At the entrance end of each is a grating for the purpose of filtration. Passing through this the water flows through the gallery till it reaches the sluices. Here the gallery is closed by a mass of masonry, through which are laid two cast iron pipes, 34in. diameter; each pipe is closed at the lower end by a self-acting valve. After passing the working chamber the water arrives at another masonry dam; immediately below this is the safety sluice. Before entering the aqueduct the water passes through a measuring apparatus. On the top of the embankment is a colossal lion, 43ft. in height, constructed by M. Félix Bouré out of 187 blocks of sandstone. The total cost of these waterworks amounted to seven million francs (£280,000).

The party then visited the controlling chamber, in which is installed a number of valves, and beyond which is an open masonry pit having a series of diminishing annular plates fixed in it in a direct line with the axis of the discharge pipe. These rings serve to break the current of the water, which becomes perfectly smooth and decants quietly over the side of the chamber, passing through fine copper wire filtering sheets in a downward direction, and then flowing through the discharge notches which serve to measure the quantity passed to the town of Verviers, and also returned into the bed of the Gileppe as compensation water. We give two views of the dam herewith. At the conclusion of the visit the party then drove back to Spa, and the members attended the banquet held at the Hotel Britannique at Spa, where a number of the Belgian engineers were the guests of the Institution of Mechanical Engineers.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

MODERN GAS ENGINES.

SIR,—We have read with feelings of surprise the statements in your Gas Engine Supplement of last week *re* vertical gas engines. We are sure that the writer of them could not have even perused the drawings of these engines which you published in your Supplement. Statements are made by him about the difficulties involved in removing the pistons from a vertical gas engine, and he recommends his readers to examine the designs so that they can see for themselves. It is a pity the writer did not take his own advice to himself, and he would have seen that by simply taking off the cylinder covers the pistons could be withdrawn without disturbing any other gearing in the slightest. That the removal of a steam engine piston is "child's play" to that of removing a gas engine piston is a statement too absurd for anyone with even a slight knowledge of the construction of the latter to make. No main water joints have to be broken, only one small water joint has to be touched, and this is indeed a very simple matter.

In buildings where vertical or horizontal engines are placed of any size, say, 150 brake horse-power and upwards, overhead lifting tackle is usually provided, and in such a case we would never dream of taking the piston of a vertical engine out by the doors of the crank chamber.

Further, the comparison your writer makes between a vertical multi-cylinder engine and a single-cylinder horizontal engine, like a good many other comparisons, is unreasonable.

The design of the vertical engine involves in itself no more complications than those due to the number of cylinders, so that for a fair comparison it ought to be compared with a horizontal engine composed of a similar number of cylinders, and in such a case we know that the complications are no greater, while from our knowledge of both designs, we unhesitatingly say that the parts of the vertical engine are simpler in themselves than those of the horizontal type.

The reference to the piston lubrication of the vertical engine is one which has somewhat amused us, as, while an excess of oil will, and has, no doubt, caused trouble, yet the remedy is such a simple one that one can only think your writer was trying to find all the possible faults when he wrote about it.

The point of the washing up of dirt or dirt falling on the piston is one which only exists in the brain of the writer. We have had vertical engines at work for over two years now doing their work of 300 brake horse-power every day for ten to twelve hours per day, and we know that the pistons of these engines have not been removed from their cylinders during that period for cleaning. The only cleaning they require is that the exposed end of the piston is scraped every three months, at the same time as the valves are cleaned—and this is with producer gas. Such a thing as "excessive friction, inefficiency, or jamming" of the pistons has never been experienced by us, and we doubt very much if it has existed at all.

Your writer should either have made himself acquainted with some few facts about vertical gas engines before he wrote about them, or left the subject alone, as a more biassed "opinion" of them it would be hard to find anywhere.

(THE CAMPBELL GAS ENGINE COMPANY LIMITED.)
HUGH CAMPBELL.

Halifax, June 27th.

[A brief reply to Mr. Campbell's letter seems to be desirable. To begin with, let us quote from the passages of which he complains. On page 11 of the Supplement, in the middle of column 1, are these words:—"We seem to have drawn up a very formidable indictment against the vertical engine; but, as these pages show, the problem is being met perseveringly by gas engine builders, and *the difficulties have already been overcome in many cases.*" We now italicise a few words, to impress them on Mr. Campbell. Our correspondent has not read our remarks very carefully, or he would have seen that in place of inviting readers "to examine the designs so that they can see for themselves," we ask them to "examine the design," which is quite a different matter. It is the design in general, and not the particular designs illustrated, to which we direct attention. We do not see how there can be any question about the greater ease of removing a horizontal than a vertical piston, even when a crane for the latter purpose is provided. Mr. Campbell admits that he would never dream of taking the piston out through the crank chamber under such conditions. He has then to break a joint, an unnecessary operation with the single-acting horizontal engine, from which the piston can be withdrawn through the open end. Without discussing other points in detail—Mr. Campbell's letter shows that he has overcome troubles which are generally admitted—we may ask why, if it offered no more difficulties than the horizontal, the vertical engine was not made by all the leading firms as a regular thing for many years past? That there would be a demand for it is hardly doubtful.—ED. THE E.]

SIR,—In the interesting review of modern gas engine practice contained in your Supplement of this week, I note that you make a strong point of water injection. Perhaps some results of my own in this connection may be interesting. The water injection was used in three vertical three-cylinder compound engines, for some six months, these engines were working on a continuous full load by day and about two-thirds load by night. I found, however, that although the engines worked with a slightly better effect with the injection when clean, they in each case after about four or five weeks developed symptoms of pre-ignition with back firing, and at the week end on being opened up were found to be incrusted all around the walls of the combustion chambers, which looked almost like the interior of a boiler. Of course after a thorough scraping out the engines were good for another run of 500 hours or so. The water used was Newcastle Deep Dene town supply, which is by no means so hard as to be experienced in many parts of this country.

The method used for the injection was by attaching a regulator screw valve to the gas inspirator and connecting same to a constant level float cistern, as used in carburetters. The feed of water spray induced was thus directly in proportion to the volume of gas and air admitted to the cylinders past the throttle. I may say these engines were illustrated in THE ENGINEER of December 12th, 1902. As regards quantity, I found each engine would take roughly about ten gallons per hour, which was equivalent to approximately one pint per 1 horse-power per hour.

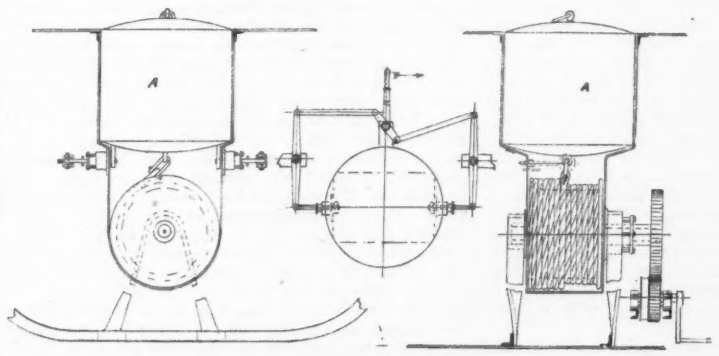
From my experience of water injection which I have tried in several ways, I have arrived at the conclusion that in order to be practically successful the water must be free from impurities to avoid deposit on long runs, entailing the necessity for an evaporator and condenser worked by the exhaust gases.

June 24th. EDWARD BUTLER.

THE SALVAGE OF SUBMARINES.

SIR,—The third submarine disaster, that of the A 8, has led me to consider whether it is possible to devise an arrangement by which those imprisoned within a submarine which has unwittingly been sunk in, say, 100ft. of water can communicate with the surface in an effectual manner, namely, by at once sending up a couple of steel hawsers strong enough to lift the vessel whilst she still contains a hullfull, or half full, of air, and I have, subject to further modification, schemed out the arrangement shown in the sketches annexed. A A are two plate steel buoys 3ft. in diameter by 2ft. 6in. deep, having each a displacement of about 17½ cubic feet, weighing each about 4 cwt., and having a lifting capacity of about 5 cwt., above their own weight; securely shackled to the under side of these buoys would be, say, 20 fathoms (120ft.) of 5in. steel rope, with a breaking strain of 108 tons.

In the bottom of the recess or housings provided for the buoys



SALVAGE GEAR FOR SUBMARINES

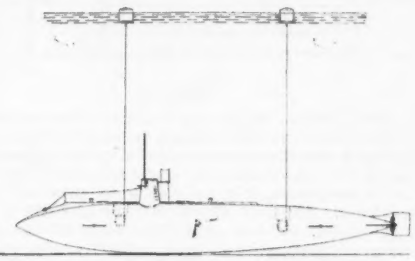
a semi-circular trough would contain a steel winding barrel for coiling the rope; the cylindrical buoy-housing and trough below would be part of the skin of the ship—a recess in the deck, in fact. The end of the shaft of the barrel carrying the gear wheel would pass through a stuffing-box into the interior of the boat, and would there be provided with gear and handles for winding the rope on to the drum, and a brake to control its release, and an indicator to show how much rope had run off.

In ordinary seafaring or diving order the tops of these buoys would be flush with the decks, and only the top ring bolt would project above. The buoys would be firmly held in position by a double grip jaw engaging two lugs attached to the buoys.

If from any chance a submarine suddenly or gradually got beyond control, and sank in water not more than 120ft. deep, those in charge would cut the lanyards controlling the trigger lever of the grips, and would then pull on the lever, when the buoys would at once float upwards to the surface, apprising those above of the direction and of the exact whereabouts and lie of the submarine, and if the other vessels were provided with boat cranes, or any tackle over which a steel hawser would run, these buoys could be lifted, and the steel shackle coupled—below the buoys—on to a steam winch, and the boat be quickly lifted to the surface, so that the conning tower would be clear of the water. If a lighter hawser would serve the purpose, the size and weight of the buoys and steel rope barrel would, of course, be reduced.

A modification of this, by which a light buoy and light steel rope are run up to the surface, and a strong rope pulled up after it, is obvious, but, unless the rope first sent up is strong enough to lift by, there is the fear that, in the eagerness of those above water to salve the boat and its inmates, it might be broken by injudicious heaving.

As it seems scarcely likely that the field of work of submarines will ever be in deep water—deeper than, say, 120ft. to 150ft—and as, if they work in water deeper than this they may possibly collapse, I have only provided for salving them from a moderate, reasonable,



SALVAGE GEAR FOR SUBMARINES

and workable depth—such a depth, in fact, as that in which those lamentable disasters usually take place. Had such lifting powers been available in the case of the A 1, near the Warner lightship, or in the A 8, the vessels could have been at once, within half an hour, brought to the surface, and all lives saved.

I abstain from all comments on the structure of the boats which renders the opening of a hatch nearly awash a necessity when men have to pass in and out, and on the regulation which compels them to wear a dress in which it is next to impossible to swim.

It is evident that when submarine boat drill takes place, a salvage vessel, with all diving apparatus, and with lifting apparatus, should accompany the boats.

I have shown one form of release gear for the buoys with a lever, which I prefer.

Westminster, S.W., June 27th. STEPHEN H. TERRY, M. Inst. C.E., Assoc. Inst. Naval Architects.

JAPAN'S HOSPITAL FOR SHIPS.

SIR,—Being well acquainted with Japanese shipbuilding yards, I should like to make a few remarks about the account from a Russian paper, of which you gave a translation in your last issue, lest your readers may take it too seriously.

First of all, the Mitsu-Bishi yard at Nagasaki is not the main point of rendezvous for the Japanese navy. This yard is a private one, and seldom touches naval work, only doing so when the Government yard, which are at Kure and Sasebo, are too full up. At these latter places the navy has splendid dock accommodation of its own, and foreigners are never allowed to go through. M. Krazheffaki could not possibly get into these establishments; the regulations are too severe; and so he has had to content himself with a description of the private yard at Nagasaki, into which there would be no obstacle against his going. The large talk about his "enterprise" is most amusing to those who have been out East.

The story about the Yaroslav is nonsense. The dock at Nagasaki cannot be pumped out under three hours. "Russian sailors" of the Volunteer Fleet evidently have imaginations. The two parts of the Mitsu-Bishi yard are at Akonoura and Tategama—see the text. The statement that the mechanics at this yard speak English is very far-fetched. There are not half a-dozen Japanese in the yard who have ever left Japan. The foremen speak English. The notices in the offices are often posted up in English, but all notices and instructions to men are posted in Japanese. It is quite outside the bounds of reason even to expect otherwise. Lots of Japanese in the large towns have picked up a few English phrases, but the Jap journeyman, on the average, knows as much English as the English mechanic knows of French.

Derby, June 24th. AN ANGLO JAPANESE.

SUBMARINE BOATS.

SIR,—The recent accident to the submarine A8 in Plymouth Sound suggests to my mind a method of at least offering some hope of escape to the crew of a submarine boat which is unable to regain the surface. It is applicable, of course, only where the depth of water is not enough to crush life out of the men. Let the boat carry for each of the crew a diver's helmet fitted with a reservoir of highly compressed air or like means of sustaining life for as much, say, as twenty minutes. Give the crew power to flood the boat with great rapidity, so that once settled on the bottom she may be filled with water, the hatches removed, and the men liberate themselves. Whether such helmets might be worn continuously during service or merely available for emergencies would be a matter for naval men. I never was in a submarine boat, but imagine that, with such means at hand, in A8 every man might have safely arrived at the surface, and had a sporting chance of being picked up. Anyhow, the horrible fear of suffocation below water would be lessened if boats had such an equipment. The idea may be worth considering perhaps.

53, Victoria-street, S.W., June 22nd. C. SCOTT SNELL.

TRIPLE *v.* TWIN SCREWS.

SIR,—In view of the fact that so many ships "turned turtle" in the battle of the Sea of Japan, it would be interesting to know if any of the newer Russian battleships were fitted, like all the larger ships of the German navy, with three propellers and three sets of engines. If this was so, then the internal sub-division of the ship required by the sub-division of the motive power into three instead of two units has not had the effect of reducing appreciably the liability of the ship to capsize when torpedoed.

If it does not have this effect, what advantages do the Germans claim for their triple screws as against the more usual twin screws, beyond the obvious one that after two engines have been disabled one still remains serviceable? That there is believed to be a substantial advantage is proved by the fact that the French have adopted this principle in their more recent ships, and by the silence with regard to it which is observed by both Powers.

June 22nd, BEOBACHTER.

RAILWAY MATTERS.

ON and after July 1st the new standard time will be introduced on all railways in India. This time is 5½ hours in advance of Greenwich.

AN American firm has received an order for 900 box cars for delivery to the Japanese Government. The cars will be 3½ft. gauge, 15ft. long, and will have a carrying capacity of about 7 tons.

THE North-Eastern Railway Bill, providing for the construction of a number of works, including dock works at Hull, has been ordered to be set down for second reading, having passed all stages in the Commons.

THE Bury section of the Radcliffe tramways was finished last Friday, and on Saturday afternoon the service of cars was started. Representatives of the neighbouring towns were invited to the ceremony.

IT is stated that the Canadian Pacific Railway will build this summer the projected line from Golden, B.C., to Fort Steel, near the line of the Crow's Nest Pass Railway. The branch line will be known as the Kootenay Central Railway.

ON Saturday the London and North-Western Railway Company will introduce, for the first time in its history, a service of non-stop express trains between London and Liverpool, which are to cover the distance of 201 miles in 208 minutes.

THE most important and interesting development of the year in Corea has been the rapid extension of the railway system throughout the country, one result of which will be greatly to stimulate trade by bringing the ports into easier communication with the interior.

THE Midland Railway Company owns 2935 engines, 5386 carriages, 56 dining and 34 sleeping cars, and 118,139 wagons. The annual train mileage reaches 47,397,249 miles, and the number of passengers carried during the last year for which particulars were published, 50,666,701.

THE railways in China, now in operation, aggregate 2235 miles. Besides these, the following roads are under construction:—Kaifong to Honanfu (Belgian), Canton to Hankau (American), Tientsin to Chikiang (German), Chingting to Singanfu (Russian), Taiyuin to Chenting (Russian).

THE *Engineering and Mining Journal* says that the progress of American practice in rolling rails has reached such a degree of rapidity that a new term, "squirt," has been evolved to describe the 15ft. per second rate. This is equal to a stream of iron rail with a velocity of ten miles per hour.

A LARGE ore storage plant is to be built for railway convenience near the Minnesota ore dock on Ganson-street, in South Buffalo. The Buffalo, Rochester, and Pittsburg Railway and the Pennsylvania system are interested in the new storage yard, which will be one of the most complete in the country.

THE directors of the North-Eastern Railway have elected the Right. Hon. Lord Wenlock a director of the company, in succession to the late Mr. W. B. Richardson. Lord Wenlock has previously occupied a position on the Board, which he resigned on proceeding to India as Governor-General of Madras.

THE Metropolitan and Metropolitan District Railway Companies have definitely decided to commence running electric trains on the "inner circle" on Saturday next. At the present time fourteen trains are continually traversing this section of underground London. Of these trains, nine belong to the Metropolitan Railway and five to the Metropolitan District.

THE British Consul at Calais states that during the strike in the Northern French colliery district—Pas-de-Calais and Nord Departments—1902-3, the Northern Railway largely imported British coal, which was distributed over their lines. They appear now to import only Welsh small coal, used in making patent fuel, principally used on their locomotives.

THE Intercolonial Railway of Canada will shortly erect large new shops and also a new building for stores and offices for the mechanical department. The new shops will cover a plot of 150ft. by 434ft., and will, it is said, be the most complete in Canada. The erecting shop will have twenty-four pits, and will have a 130-ton electric crane for lifting locomotives, besides other first-class equipments.

FROM an extract of the report of the Central South African Railways published in the *Cape Argus* it appears that the total length of railway, including double and treble track, open for traffic at the end of last year was 1540 miles. There were 403 miles under construction, and 711 projected. When all the branches are finished, the approximate length of the system will be 2654 miles.

A FIRM of Belgian bankers has recently formed a company with the object of building an electric railway line between Rome and Civita Castellana. The capital of the company is £140,000. The distance between Rome and Civita Castellana by the existing railway line is about 50 miles, and the proposed new line, which follows a regular and direct track, will shorten that distance by 15 miles.

THE Great Northern Railway Company of Canada carried its Bill for extension work in the West a stage further on Thursday, the Committee of the Dominion House of Commons passing it by the narrow margin of the chairman's vote. Strong opposition was made to the Bill by the powerful interests supporting the Canadian Pacific Railway, which seeks to hold a monopoly in the southern part of British Columbia.

THE total import into Corea last year of railway plant and material, according to the Customs returns, was £472,951, and of this sum probably some £200,000 was of British origin. The energy of railway construction during 1904, however, makes these amounts abnormal, and though, till the completion of the railways, imports will continue to be large, British trade under that head must expect to suffer a decline eventually.

ACCORDING to the *Street Railway Journal*, the Pennsylvania Railroad has commenced the construction, at its Juniata shops at Altoona, of the first of its electric locomotives to be used at the New York terminal. The locomotive is to be built in two sections, each having four 65in. drivers, and the length over all is 37ft. 10½in. When the frame is completed it will be sent to the Westinghouse Works at Pittsburg for electrical equipment.

IT is reported that the Pennslyvania west bound 18-hour train recently covered three miles near Ada, Ohio, in 85 seconds, which is at the rate of one mile in 28⅓ seconds. If this is so, then the speed attained was something over 127 miles an hour. It will be remembered that on the Berlin—Zossen military road the highest speed reported was 117·32 miles an hour, as a maximum recorded on a trial run of the electric car over a specially prepared piece of line 14·5 miles long.

THERE is now a fifteen-minute service of electric trains on the South Harrow branch of the District Railway, instead of the half-hourly service which has hitherto been run. The power is supplied from the Chelsea generating station, instead of from the temporary plant at Alperton. The working of the Hounslow line electrically began on Tuesday. The Chelsea power station may now be regarded as ready for working the whole of the District Railway as soon as the new rolling stock is complete.

NOTES AND MEMORANDA.

A JAPANESE observatory has been built at Chemulpo, and was opened in March, 1905.

IT has been observed that the elongation and tensile strength of steel castings of given carbon, like those of crucible steel, correspond with those of Bessemer and open-hearth of lower carbon.

OIL or fat is said to exert a most destructive influence on Portland cement. The result shows in coarse cracks, weakening and even disintegrating the mass in the course of one to several months.

THE Board of Trade and Trinity House have concluded a contract with Marconi's Wireless Telegraph Company, Limited, providing for the equipment of lightships with Marconi wireless telegraph installations.

SOME three or four years ago Newcastle coal used to be sent to the extent of 4000 tons yearly to Agram, Croatia, from Fiume for the gas works there. The quantity has since decreased to 1500-1800 tons yearly.

DROP in temperature of superheated steam in well lagged mains has been found by Dr. Berner, of Berlin, to be from 0·3 to 1 deg. per foot of length, and varies inversely as the diameter of the pipe and the steam velocity.

ACCORDING to a German periodical, Herr Biedermann, as the result of an elaborate calculation, computes the cost of a cubic metre of brick masonry at M. 28, and of ashlar at M. 23 at least, whereas the cost of concrete falls below M. 15.

THE total number of cases and cans of petroleum shipped at Batoum in 1904 was 9,881,096 cases and 5,068,180 cans, against 9,035,483 cases and 4,624,021 tins in 1903, showing an increase of exports under both these heads of 845,613 and 444,159 respectively.

STEAM turbines are commonly supposed to require that the supply of hot vapour be furnished at a high pressure; but a recent innovation proposes to use exhaust steam on low-pressure turbines. This phase of economy in prime movers will be watched with much interest.

DURING the last year the gold output from the Yukon region has been decreasing, the loss from the preceding year being 1,329,825 dols. It is stated that the Dawson territory is no longer profitable for small mining operations, but can still be worked to advantage on a large scale.

IN a paper read recently before the Chicago branch of the American Institution of Electrical Engineers the author shows that with small carbons a large increase of light results, probably owing to the fact that the crater is less obscured, and that the light is subject to less fluctuation.

THE diamond drill bores in India have been quite eclipsed by the Calyx bore put down by the East Indian Railway at Durgapur station between Raniganj and Burdwan. The depth attained is 2149ft. The object of the boring was to test the eastward extension of the Raniganj coalfield under the Damuda alluvium.

A TEST made at Purdue University of composite bricks made at Indianapolis of sand, cement, and lime, showed a crushing strength of more than 15,000 lb., as against 1500 lb. for an average clay brick, and 3500 lb. for an average faced brick. In transverse strength the composite brick showed a resistance of over 2500 lb.

THE United States Government dry dock built by the Maryland Steel Company was successfully floated on June 2nd. This is the largest floating dry dock in the world. It will lift 24,447 tons and cost 1,125,000 dols. After satisfactory tests in the Chesapeake Bay it will be towed to the Philippine Islands for use in those waters.

CANADA has paid in bounties on iron and steel production up to April 30th in the current fiscal year, a period of ten months, the sum equivalent to £188,200; on lead, £81,430; and on crude petroleum, £44,629. In the corresponding period of the next previous fiscal year the amount paid out on account of iron and steel was £135,860.

PLATINUM, at the same time the most ductile and the most infusible of metals, is now quoted at a higher price than gold, its value having increased more than three-fold since 1890. More than half the quantity is produced by the Compagnie Industrielle du Platine, Paris, which produces a little more than 3 tons yearly, valued at £720,000, from its mines.

ACCORDING to an American paper, a new long-distance record for overland wireless telegraphy has been established by the United States Navy Department in sending messages from the station at Key West, Fla., to Chicago, a distance of 1060 miles. It seems that the best results were obtained at night. Twenty-nine stations are now established, with the prospect for many more in the near future.

A NOVEL pumping plant is under construction for the Casino, New South Wales, waterworks. The supply will be drawn from the Richmond River by a four-stage centrifugal pump in a shaft 10ft. in diameter and 55ft. deep. This pump will be driven by a horizontal tandem compound engine at the ground level, and is rated at 9700 gallons per hour against a total head of 178ft. The water will be forced into a 480,000 gallon concrete service reservoir.

ACCORDING to the patent of H. Leitner, taken out for the preliminary treatment of accumulator plates, the lead plates are subjected as anodes to the action of a high-density current in a dilute solution of a suitable sulphate, to which traces of substances capable of forming soluble lead compounds are added. After cleansing, the plates are reduced as kathodes in a suitable electrolyte. Finally, the finely divided lead layer is oxidised by exposure to warm air.

RECENT experiments by P. Massoulier describe the conductivity of a burning stream of air saturated with ether vapour. The conductivity was greatly increased by blowing carbon dioxide into the jet. This may indicate the dissociation of the carbon dioxide, which seems to absorb much heat in furnishing a vast supply of ions. On the other hand, the ions may come in part from the products of reaction between the ether and the dioxide of carbon.

A SLIGHT variation of the specific inductive capacity of glass at high frequencies has been found by Signors Broca and Turchini. They found a slight decrease with increasing frequency, but were unable to measure it. They went up to three million periods per second, and used Leyden jars. Consistent results were obtained on putting into the formulæ a capacity amounting to about 0·07 times the capacity of the condenser for ordinary alternating currents.

TO prevent the dark core ordinarily formed in the centre of blocks of artificial ice, otherwise very clear, the engineer in charge of a Southern Missouri plant devised a rather ingenious expedient. He allowed the blocks to freeze until the central unfrozen hole was about 3in. in diameter, when this hole was tapped and the discoloured water drawn off by means of a suction pump. The hole was then filled with clear water and allowed to freeze, giving a clear cake of ice. One cannot help wondering what colour the original water must have been.

MISCELLANEA.

IT is stated that the question of the adoption of an Irrigation Act for all India will be revived and advanced during the summer season of the Imperial Legislative Council.

OF the world's coal output the United States produces 37 per cent., 39 per cent. of its pig iron, 51 per cent. of its copper, 25 per cent. of its zinc, and 51 per cent. of its petroleum.

AN international exhibition of models of engineering interest, under the patronage of the King of Spain and of Queen Maria Christina, will be held in Barcelona from May to October, 1905.

THE canal and locks around the rapids of the Columbia River at the Dalles will cost £824,266. The work has been undertaken by the United States Government, and will be begun very shortly.

THE British Consul at Fiume states that the harbour extension works voted three years ago are now in abeyance owing to want of funds. The want of extended quay frontage is at times severely felt.

IT is reported that Eros, the nearest of all the heavenly bodies, with the exception of the moon, has been photographed by means of the Bruce telescope at the Harvard Observatory at Arequipa, Peru.

THE Peruvian Government have placed an order with Vickers Company, of Barrow, for a cruiser of 24 knots speed, closely resembling but slightly larger than the Scout, Sentinel, and Skidmisher, which were built by the company for the British Navy.

WE are informed by the secretary that the Morecambe—Regent-road—West End Pier Company, Limited, is about to re-connect the severed portions of its pier in a substantial manner. It may be remembered that a breach was made in this pier by an unusually severe storm two years ago last February.

THE Government of India have taken up and put on a solid basis the irrigation schemes of the future. They propose that £30,000,000 shall be spent in twenty years on these works, divided as follows:—£10,000,000 on productive works, £14,000,000 on protective works, and £6,000,000 on intermediate works.

WE understand that Professor H. C. Sadler, of the University of Michigan, will shortly start for Europe, where he will investigate and study the experimental model marine testing tanks that have been established there. The experimental tank at Ann Arbor is now nearly completed, and the model cutting machinery is about ready.

AT a meeting of the Council of the Cleveland Miners' Association, held at Middlesbrough last Monday, it was decided to direct the Executive Committee to formulate an old age pension scheme for aged miners. It was also resolved that a further claim be made for a twelve o'clock Saturday, and that eight hours constitute a shift for all classes of men and boys.

THE British Consul at Copenhagen states that the British coal trade in Denmark will undoubtedly be increased in proportion as Denmark's trade and industry increases, especially if the British export tax on coals is not increased. German coals are not handicapped by any export tax as the British coals, but their quality is very bad and they are unsuitable for most purposes.

THE entrance to Grays Harbour, Washington, was improved some time ago by the construction on the south side of a rubble stone jetty 13,784ft. long, which is to be extended to a length of 18,200ft., and which, in conjunction with a similar jetty on the north side, will, it is believed by the United States engineer, give a depth across the bar of 24ft. at low water. This is an important harbour with a large trade, principally lumber.

THE annual report of the Chief Inspector of Factories and Workshops for the year 1904, just issued as a Blue-book, states that at the end of the year there were 104,472 factories and 145,172 workshops upon the registers, including laundries, but not men's workshops, docks, warehouses, or—in general—domestic workshops. The approximate numbers of persons employed in factories and workshops are 4,000,000 and 700,000 respectively.

THE engineer of the Association Normande des Propriétaires d'Appareils à Vapeur, M. Maréchal, who has carried on interesting investigations on the steam engine and the proportion of calories actually utilised, has arrived at the conclusion that, even with the most perfect systems, as much as 59 per cent. of the total heat developed goes to the condenser. When the engine is exhausting to atmosphere 63·6 per cent. of the heat is dissipated.

THE annual report of the Indian Patent-office for 1904 shows 552 specifications filed, as against 536 in 1903. The range of the inventions for which protection is sought covers nearly all arts and industries, but the leading place, says *Indian Engineering*, is easily taken by transport, to which 90 applications related. Two hundred and two applications were filed by residents in India, 67 being made by natives. The remaining 350 came from outside.

THE motor car service between Darlington and Swaledale—Richmond, Reeth, Gunnerside, and Keld—will, it is fully anticipated, be started to-morrow. The National Road Traffic Company, of which the Marquis of Zetland is the principal director, will open to more ready access a very beautiful countryside. The company has secured the contract from the Post-office for the carriage of the mails, and this will provide the bulk of the first year's revenue.

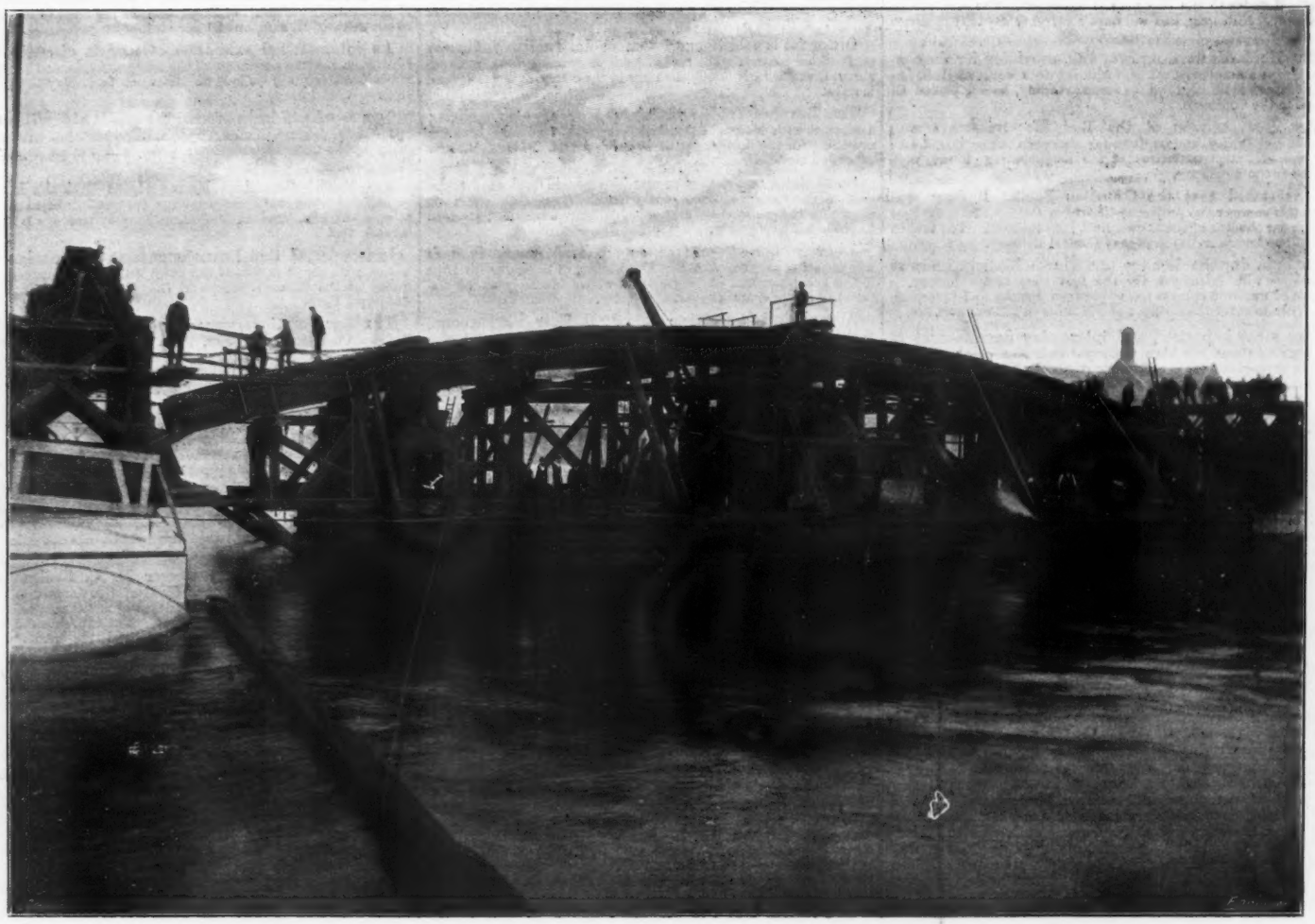
A VERY handsome and valuable challenge cup has been presented to the British Motor Boat Club, which will be raced for in the Solent on August 7th, on the occasion of the visit of the French fleet to this country, and the cup has been appropriately named by the donor the "Entente Cordiale" cup. The cup, which has been presented by Mrs. Walker Munro, will be allotted to an event for racing boats not exceeding 40ft., built or owned in England or France, no time allowance being given, and the competitor winning the cup twice in succession or three times in all wins the cup outright.

IN the report of the Executive Committee of the Rhodesia Chamber of Mines it is stated that the most noticeable feature about the native labour returns is the large increase in the number of local natives employed, which satisfactory state of affairs is said to be largely due to the exertions of the Rhodesia Native Labour Bureau. The returns for April, 1904, show that 27·09 per cent. of the gross number of boys employed were local, while in March, 1905, 39·46 per cent. were natives of Southern Rhodesia. The steady increase in the total number of boys employed points at once to greater willingness to go out to work, and also to the expansion of the industry.

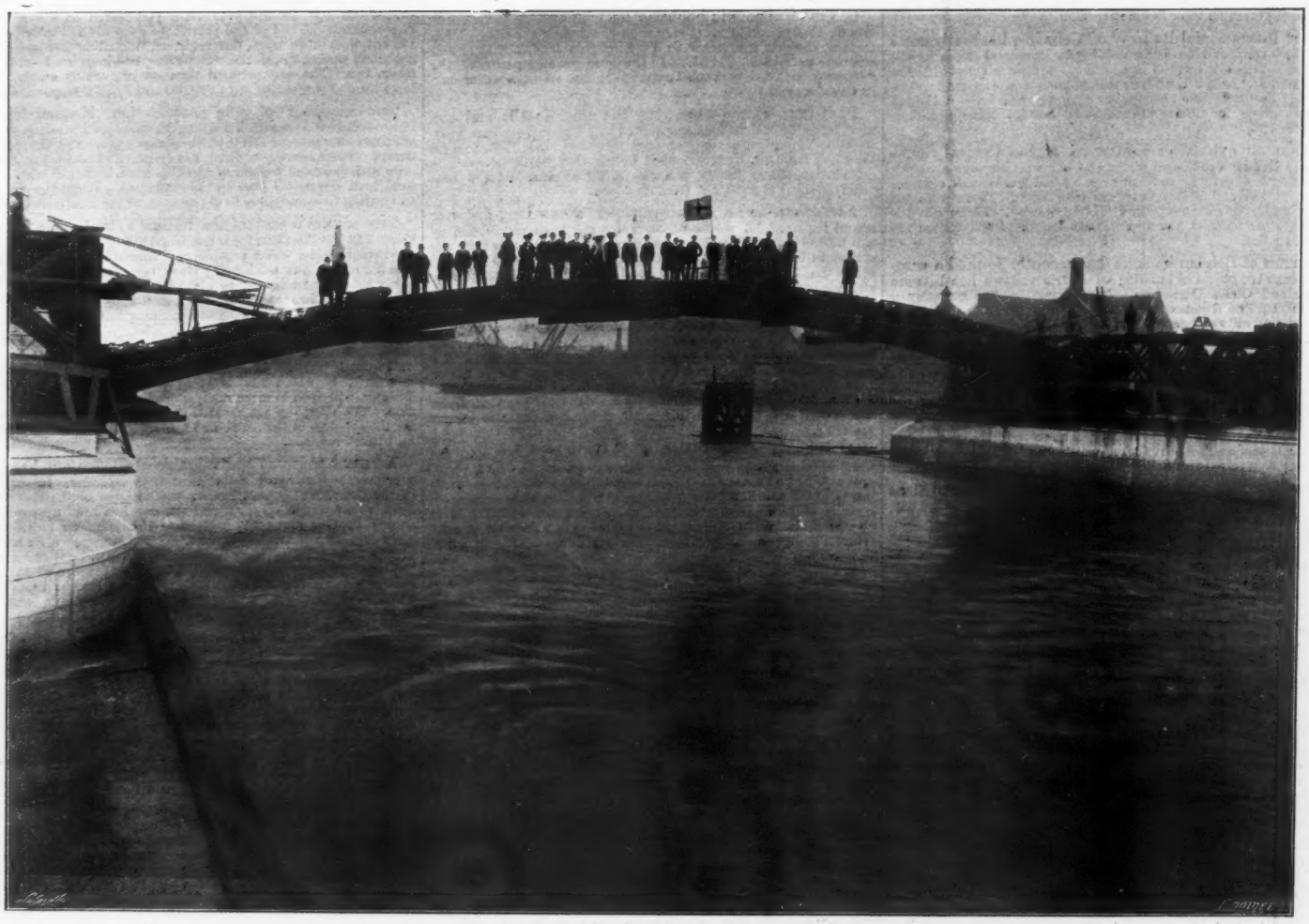
THE courtesy of permitting visitors to inspect power stations is almost universal upon American electric railways, but beyond the usual cautionary stipulations the reverse sides of passes seldom bear any significance. According to the *Street Railroad Journal*, an interesting exception occurs in the passes in force in Baltimore, which state that "any suggestions or advice as to the care, management, or operation of this plant are earnestly requested." Here the company recognises that many unusual features of operation are often apparent to strangers, which would pass unnoticed by the regular staff, and in its willingness to receive suggestions for betterment, the company exhibits a liberality that deserves favourable comment.

THE NEW VAUXHALL BRIDGE

(*For description see page* 641



FLOATING AN ARCHED GIRDER INTO POSITION



GIRDER IN PLACE

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CONTENTS.

THE ENGINEER, 30th June, 1905. PAGE

MACHINE TOOL DESIGN. No. IX. (Illustrated.) 639
NEW VAUXHALL BRIDGE. No. VI. (Illustrated.) 641
PROGRESS OF WARSHIPS AND MACHINERY BUILDING IN ENGLAND .. 643
SIMPLON TUNNEL MEDAL. (Illustrated.) 644
THE ROYAL AGRICULTURAL SHOW. (Illustrated.) 644
OBITUARY 645
THE INSTITUTION OF MECHANICAL ENGINEERS. (Illustrated.) 646
LETTERS TO THE EDITOR—Modern Gas Engines—The Salvage of Submarines—Japan's Hospital for Ships—Submarine Boats—Expansion of Steam 648
RAILWAY MATTERS 649
MISCELLANEA 649
NOTES AND MEMORANDA 649
LEADING ARTICLES—A Battle of the Ports 651
Indian Railways 652
Is Machinery Rateable? 652
A French Commerical Congress 652
Chicago and Typhoid Fever 653
Locomotive Coal Contracts 653
LITERATURE 653
THE LIEGE EXHIBITION. (Illustrated.) 653
ROYAL SOCIETY CONVERSAZIONE 654
DOCKYARD NOTES 654
BOOKS RECEIVED 654
NEW MARINE TYPE BOILER. (Illustrated.) 656
RESERVOIR IN THE SIHL VALLEY 657
PORTABLE SUCTION GAS PRODUCER AND ENGINE. (Illustrated.) .. 657
AN INVESTIGATION TO DETERMINE THE EFFECTS OF STEAM-JACKETING UPON THE EFFICIENCY OF A HORIZONTAL COMPOUND STEAM ENGINE. (Illustrated.) 657
THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS 658
NOTES FROM LANCASHIRE 658
THE SHEFFIELD DISTRICT 659
NORTH OF ENGLAND 659
NOTES FROM SCOTLAND 659
WALES AND ADJOINING COUNTIES 659
NEWPORT HARBOUR COMMISSIONERS' WEEKLY TRADE REPORT 660
NOTES FROM GERMANY 660
AMERICAN NOTES 660
TRADE AND PERSONAL ANNOUNCEMENTS 660
NAVAL ENGINEER APPOINTMENTS 660
CATALOGUES 661
LAUNCHES AND TRIAL TRIPS 661
BRITISH PATENT SPECIFICATIONS. (Illustrated.) 661
SELECTED AMERICAN SPECIFICATIONS. (Illustrated.) 662

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☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

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☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

REPLIES.

E. B. (Hampstead).—We cannot venture to answer your question. Good men make a way for themselves, but if you have no connection it may be slow work. There is no lack of consulting engineers in London.

R. M. (Brighton).—The smallest railway in Great Britain, with the exception of mere models, is that at Festiniog in North Wales. It is used in connection with the quarries, but has also some passenger vehicles.

A. F.—(*a*) See the *Journal* of the Franklin Institute, for November, 1857. (*b*) See Haswell's paper in the "Proceedings" of Institute of Civil Engineers, vol. cxv., and Atkinson's remarks on Anderson's paper on the "Antwerp Waterworks," vol. lxxii., page 53, of the same "Proceedings."

R. S. (Penge).—None of the patent mixtures is better than ordinary "killed acid," which is made by putting a few chips of zinc into a little hydrochloric acid. Brass or iron can be soldered readily by its use. Silver solder is more readily fused than spelter, and borax is used as a flux. It costs 3s. 6d. the ounce, and is sold in sheets which are cut into thin strips for use.

X. (Kilburn).—(1) You had better see the article on the "Heating of Buildings," in the *Encyclopædia Britannica*, vol. xi.; and the late Sir William Anderson's paper on "Hot-water pipes," in the "Proceedings" of the Institution of Civil Engineers, vol. xlviii. The temperature of steam at 60 lb., or say, 75 lb. absolute, is 307·5 deg. Fah., and its total heat = 1175·2 units per lb. from water at 32 deg. Fah. That is to say, in condensing to water at 32 deg. Fah. it would give out 1175·2 British thermal units. You will find tables and a lot of useful information in D. K. Clark's "Manual of Rules and Data for Engineers." (2) The pressure is in square inches, but as it is represented by a difference of head, the area of the tube is of no consequence. The pressure of 1in. of water is ·5773 ounces per square inch.

THE ENGINEER.

JUNE 30, 1905.

A BATTLE OF THE PORTS.

THERE are not wanting indications that before very long the looker-on, whose tastes lie that way, will be able to enjoy an exhibition of keen competition between some of the chief European ports; and not the chief only, for into the battle will possibly come others which are to-day regarded as little else than second-rate. There was, perhaps, never a time when more energy was being displayed in connection with dock construction and extension. London may better be left on one side, for keen competition with her there has been ever since the opening of the Suez Canal and the coming into the industrial arena of the Continent. The Thames will always command a large traffic, if for no other reason than that on her banks is situated the largest city in the world and the capital of the greatest Empire. Still some of that trade which she at present continues to enjoy will be diverted to ports more favourably situated and which are able to accommodate customers on cheaper terms. Southampton, which at one time was as distinguished for progressiveness as under the reign of the old dock company it was conspicuous for the opposite, is apparently, for the moment, at a standstill. We all know that liners continue to arrive there and take their departure periodically from the magnificent Ocean Quay, but we have Dover making bold bids for, and attracting, both African and Transatlantic traffic from the South-Western's docks. It is true that the authorities of the Kentish port are ceaseless in proclaiming that they have the Kaiser to thank for the new trade which is coming their way, but one may rest tolerably well assured that it is not sentiment which has impelled William II. to look with favour on the endeavours of Sir William Crundall. There must be some sound business reason for the visits. Although up to the present we have heard only of passengers in connection with the port, cargo to at least some extent will certainly follow, and it is presumably Southampton which will be the loser. Southampton has also lost the inward calls of the German Transatlantic Lines and of the American Line, which now call first at Plymouth. That course will be continued so long as the steamers make Cherbourg a homeward port of call, and we have reason to believe that there are no indications of any change being made there. It seems reasonable to suppose that with this foundation such a progressive railway company as the Great Western will exert all the endeavours in its power to build up an important edifice.

Will any traffic be diverted from Liverpool? Notwithstanding the failure of the Mersey Docks and Harbour Board to secure its Bill for an alteration in the method of levying harbour dues on big passenger steamers, there is no reason to believe that all is peace between the Cunard Company and the port authorities. It will be remembered that following upon the speech of Lord Inverclyde at the annual meeting of the Cunard shareholders considerable discussion ensued on the possibility of the leading Transatlantic line making a move to quarters elsewhere with, at any rate, a portion of its trade. As an inward port for American passengers Liverpool has little to recommend it save what may be termed the claims of long descent. For passengers desirous of going to the North of England or Europe, Heysham seems to possess attractions. It is hardly justifiable to suppose that the Midland Railway Company went to the enormous expense it did over its new dock works there merely for an Irish traffic, already very much cut up. For South Country passengers it used to be the custom to pit Southampton against Liverpool. Plymouth may for the moment be put into the place of Southampton. But the latter port will, we should imagine, wake up again before long, when we shall have two South Coast ports asking why waste time in calling at Queenstown, or in travelling on to the Mersey, only to take a railway journey back to the South? Then, again, we have the Great Western Company indulging in great harbour works at Fishguard, nominally for the Irish trade. Can the poverty-stricken island find enough traffic for all the pursuers of its favours? Furthermore, as far as the Transatlantic trade is concerned, sight must not be lost of what is happening on the Continent. All the great ports there are developing and, what is more, the steamer lines serving those ports are making much greater strides than are any of ours. We have two huge and speedy Cunarders building, which may prove wonderful successes or may not. But we have nothing else on the way, whilst the Germans are adding to their Atlantic fleets steadily. England will always attract a certain number of passengers, but there are others whose homes are on the other side of the channel, while the American visitor will easily get into the way of stepping off at the terminal port of the huge and luxurious steamer which attracts him for the sea passage.

In other trades we shall assuredly witness some sparring in the Humber. The Great Central Company is developing at Immingham; the North-Eastern at Hull, while it is tolerably certain that the Lancashire and Yorkshire will take a little more interest in Goole now that it has embarked in shipowning. The fight in the Humber will affect the Tyne ports unless they bestir themselves, and presumably all the spirit has not left Newcastle; one can hardly picture it content with a deserted Quayside. In Scotland there are no indications of any events out of the ordinary. The reconstitution of the Clyde Trust is little other than a putting of the house in order. It is, however, another matter in the Bristol Channel. Here we have Bristol herself engaged in spending a large sum in new dock works, and recent indications point to fear on the part of the authorities that growing trade is not quite so assured as they at one time thought. To meet the difficulty they are talking of building their own fleet of steamers. The remedy seems somewhat of the forelorn-hope order, but it is to be expected that endeavours will be made to prevent the new dock presenting such a dreary waste of water as Portishead affords to-day. The Welsh coal ports are brightening up. Of recent years Newport has taken a new lease of life, and promises to become the sort of place Sir George Elliott may have hoped for when he concerned himself with the Usk. There are extensions on the way there and more are talked of. At Cardiff we have a huge new dock, and, to the disgust of Bristol, the Welshmen are asking why they should receive the imports to feed their miners *viâ* the Avon? Barry Docks for the moment are comparatively quiet, but perfect peace has never been a feature of that enterprise, and one may look for some sort of an outburst there ere long. Further down the the Channel we have Port Talbot attracting trade from Swansea, which, in her turn, is committed to an important new dock work, although her present facilities are by no means exhausted. Still the money will have to be made to meet the obligations imposed by ambition, and therefore it is not to be expected that Port Talbot will be allowed to continue expanding without a sterner fight than of which there has yet been any indication. The position here has an added piquancy by the recent talk of the possibility of the Great Western Railway Company acquiring the harbour which owes its name to the at one time father of the House of Commons. Should this event ever occur, then there would, indeed, be "wigs upon the green" in the Bristol Channel. Finally, there is Llanelly, an insignificant port of itself, but which has managed to get into debt to some extent with the Bank of England, which has now appointed its own representatives on the Harbour Board. They are what the Americans call "live" men, and are likely to earn their salaries. From all which things it appears that there are not

lacking prospects of lively times amongst our ports. Money will be lost, no doubt, but the trader should benefit.

INDIAN RAILWAYS.

IT was officially stated in the House of Commons during the discussion of the question of railway loans, that the Government of India propose to make a beginning in the direction of expropriating those railways in that country which can be acquired in accordance with the provisions of the charters under which powers for the construction of the lines were granted. The decision to embark upon a policy of nationalisation may be attributed partly to the increasing prosperity of the trade of India, which is mainly due to the extension of the railway system, and also to the development of manufactures and the improvement in agriculture, and partly to the official belief that the time has arrived for exercising the powers of purchase. It is tolerably certain that a movement in this respect would scarcely have received serious consideration at the present time were it not for the general expansion in the trade of British East India during the past two or three years. The progress is shown by official statistics. These demonstrate that the value of the total trade of India, which amounted in round figures to £143,000,000 in 1902, advanced to £164,000,000 in 1903, and to nearly £178,000,000 in 1904. No less than £77,000,000 of the latter sum represent trade as between Great Britain and India, or an increase of £35,000,000 over the year 1902. These figures, although remarkably striking, are even more so when regarded from the standpoint of India as a customer for productions from Great Britain, as our exports to India advanced from £33,500,000 in 1902 to £40,000,000 last year. The latter total is equivalent to the combined exports from the United Kingdom in 1904 to Australia, Canada, and Cape Colony. The maintenance and development of our export trade with India are consequently matters of considerable importance to manufacturers and engineers in Great Britain, quite apart from the cultivation of business with other British possessions.

The increasing value of the total turnover of Indian trade is not the only factor in the situation from which the question of the State purchase of the railways is being approached at the present time, as the traffic on the lines is making rapid strides. In the case of passenger traffic, the number of persons carried increased by 14,000,000 in 1903, as compared with the preceding year, and in 1904 by 19,000,000 over the year 1903, while the quantity of merchandise has advanced by 2,000,000 tons and 7,000,000 tons respectively in the two years. It is impossible to say how far this large augmentation is due to the natural development of the older railways, or how much may be apportioned to the new lines opened in the past two years. The length of new lines thrown open to traffic in the financial year 1904-05 amounted to 623 miles, thus bringing the total mileage in operation up to 27,749 miles, whilst 3139 miles were in course of construction at the end of the year. In view, however, of the comparatively slight extent of additional mileage opened during the past year, it seems highly probable that the considerable increase in the number of passengers and in the tonnage of goods transported may be mainly attributed to natural expansion owing to the increasing prosperity of the country, which is also reflected by the large advance in the deposits of the working classes in the savings banks. Indeed, the financial condition appears to improve with the gradual extension of the railways, which in some quarters are said not to be constructed at a sufficiently rapid rate to enhance the economic position of the country.

The Government scheme of purchase concerns the Bombay and Baroda Railway in the first instance, and the Bengal Central Railway has also been taken into consideration for acquisition this year, while it will be possible in the future to take over the Mahratta Railway, the Madras Railway, and other lines, in the event of its being considered desirable to do so. Under the original charters granted to various railway companies, it is provided that the undertakings may be purchased when it is considered by the Secretary of State for India that they have yielded that amount of profits to which the owners are entitled, and when they may be taken over for the benefit of the taxpayers in India. As the shareholders in the different railways invested their money mostly under a Government guarantee and with the knowledge of the right of expropriation, they can scarcely complain of the proposal to exercise this privilege, although they may entertain differences of opinion on the subject of the adequacy of the return on their investments, unless the aggregate percentage is embodied in the charters. At any rate, the experiment in nationalisation, of which details are not forthcoming at present, is not entirely a matter for congratulation, although the purchase is expressly provided for under the charters. If the transfer of private lines to the State simply implied a change of ownership without an alteration in the regulations and policy governing the working of the lines, there might be no reason for doubts as to the wisdom of expropriation; but there is no certainty as to what State proprietorship may bring forth. The experiment, which for the time being is to be restricted to the Bombay and Baroda Railway, is embodied in a proposal to raise a loan of £20,000,000 for the acquisition of this railway and for the construction of new lines and extensions of existing railways. The amount to be paid for the railway in question now forms the subject of negotiation, but the balance should be sufficient to provide a large amount of work for British firms engaged in the production of rails, locomotives, and rolling stock in general.

IS MACHINERY RATEABLE?

As our readers are probably aware, there is a Bill now before Parliament which has been drafted with a view to settling once and for all the troublesome question whether machinery is to be rated or not. Seeing that a similar measure has been laid before the House of Commons nearly every year since 1887, we do not cherish any hope that it will be passed this session, nor any very lively hope that it will ever become law. It is significant, however, that in 1902 an Act came into force by which "loose machinery" in Scotland was expressly exempted from rating, and it is possible that in years to come the Legislature may endeavour to reduce chaos to order by a similar amendment of English rating. In the meantime, however, there is ground for hoping that something may be done by means of litigation to modify the present law. This hope is bassed upon a perusal of the report of the case of Kirby *v.* The Hunslet Union, which came before the Court of Appeal on June 22nd, on appeal from the Divisional Court. That case was originally stated by the Recorder of Leeds, and it directly raised the question whether machinery—that is to say, such loose machinery as is to be found in every mill and factory—is rateable. It also made it clear that the decision of this important question rests upon a judgment of the Court of Appeal nearly twenty years ago, which has never—so far as we know—been discussed in the House of Lords.

The case is of such importance that a statement of the facts is well worthy of perusal. The appellant was the occupier of certain buildings, known as the Standard Works in Hunslet, where he carried on the business of a general jobbing engineer. The gross estimated rental of the property was £67, and the rateable value of buildings, &c., £45. Before the above rating the appellant was assessed at £29 gross and £22 rateable. He appealed from the decision of the Assessment Committee to the Recorder of Leeds. It is necessary at this point to state that the appellant's property consisted of an office, a model room, a fitting shop, a machine shop, a store, an engine room, a shed, and a yard, all of which, except the office, model room, and store, contained machinery. Some of the machinery, such as a horizontal steam engine, certain shafting, and pulleys, admittedly formed part of the freehold, and was therefore properly brought into rating, but there were a number of machines which did not come in this category, and which had been placed there by the tenant or his predecessor in the title for the purpose of making, and which did make, the property fit for the particular purpose for which it was used. On December 31st, 1891, the appellant agreed with Benjamin Greaves, the owner of the property, to take it complete as it stood on lease for five years at a rent of £26. After 1896, he continued to remain as a tenant from year to year. He disputed the new rate on the following grounds:—"(1) That in valuing premises the valuer or the user of the machinery, other than that which forms part of the freehold, ought not to be considered; (2) that the said machinery ought only to be taken into account in so far as its presence (*a*) affords proof that the premises were fit for the purpose of the business carried on therein, and (*b*) would be likely to induce a tenant to give a higher rent for the premises than he would give if the said machinery were not upon the premises." He also contended that "machinery of the class to which the said machines belonged, if it were not upon the premises when a letting took place, would be brought and put upon the premises by the tenant to whom the premises were let and not by the landlord who let the premises, and that, therefore, it was wrong to include the value of the machinery in the annual rent which such tenant would pay to such landlord." The Hunslet Union contended—in effect—that the proper criterion was the rent at which the property would let, assuming the tenant had the right to use the machines. The Recorder of Leeds held that this contention was right. He also held—and this is the point of the case to which we desire to draw particular attention—that the value to the user of the machinery was not necessarily to be arrived at by taking the cost or value of the machinery and putting a percentage on such value, as had been done by the respondents' valuers. In fact, he appears to have purposely refrained from disclosing the way in which he arrived at his figures. He viewed the works himself, and reduced the assessment to £46 as the gross estimated rental and £31 as the rateable value. He also pronounced that if the appellant's argument should be sustained, the gross value was £39 and the rateable value £26. The Divisional Court and now the Court of Appeal have upheld the Recorder's decision, the Master of the Rolls—in the latter case—saying that the case was governed by the Tyne Boiler case, which was decided in the Court of Appeal in 1886.

The Tyne boiler case is so well known that we need not refer to it except to say that it is the leading authority for the proposition that loose machinery is to be taken into account as enhancing the rateable value of the property where it is found; but it does not lay down any principle upon which the enhancing value of machinery is to be estimated. Nor is there any other case which does this. It appears to be settled now that each Court of Quarter Sessions must work out this difficult point for itself; and provided the bench of magistrates—or the recorder of a borough, as the case may be—gives no reason for a decision, that decision is final. This is an exceedingly unsatisfactory state of the law. To take an illustration. What is there to prevent the Court taking the value or the profit-earning capacity of the machinery into consideration in order to arrive at the rateable value of a mill? Having regard to the decision in the Tyne boiler case, it appears to us that the Recorder of Leeds and the Court of Appeal came to a correct conclusion as the law now stands; but it is quite within the power of the House of Lords to reverse the principle of the Tyne boiler case if the Hunslet case is brought before them. Whether they will do so is another matter; but we have said enough to show that under existing conditions there is no certainty of uniformity in the law of rating as applied to machinery.

A FRENCH COMMERCIAL CONGRESS.

WHILE the French trade returns during the last few years have not shown any appreciable falling off in the aggregate consignments of machinery and metallurgical products generally to foreign countries, there has nevertheless been a good deal of complaint about the way in which France is supposed to be losing her hold on the international markets. The situation is especially precarious when we come to look at particular branches of industry, such as sugar-making machinery, in which France formerly did a very large share of the world's trade. By the facilities they offer to customers the German sugar machinery engineers have supplanted the French in nearly all cases, except where sugar factories are run with French capital or are under French management, and the revival of the cane sugar industry has so far brought little activity to the engineering works on the other side of the Channel. In railway rolling stock, also, the business is going chiefly to the Belgians and Germans, and there are few branches indeed in which the French have lately been making so much progress as their continental rivals. They attribute this diversion of foreign trade to other countries to the superior organisation of the German industry and to the facility which manufacturers possess for putting themselves into direct touch with buyers. With a view to providing equal facilities for the French industry, a Parisian journal recently took the initiative in convening a national congress, in which all the various manufacturing industries participated. A very exhaustive programme was divided up into sections and discussed by different committees, and the results of their deliberations were summarised in a report presented at a general meeting by M. Rousselot, member of the Republican Committee of Commerce and Industry. The report proposed the formation of a permanent committee, which would develop the various conclusions of the congress and carry them into effect as far as possible, while it is to draw up another programme to be presented at a second congress to be held in Paris in 1906. Among the reforms particularly recommended is the improvement of the inland waterway system, which

is already being developed under the project adopted by the Government about two years ago, whereby the Loire is being deepened up to Nantes for sea-going craft, and the rivers and canals connected up to form a continuous system; and it is also proposed to replace the existing consuls with "consuls-courtiers"—literally, "consul-brokers"—who will be required to look after the interests of French commerce and industry in the countries to which they are appointed. At present these interests are chiefly in the hands of "conseilleurs du commerce extérieur." This is a purely honorary appointment, and the position is held by traders and others abroad who are naturally inclined to favour the interests of the firms they represent, while their experience does not usually extend beyond their own special branch of commerce and industry. The consul-courtier, on the other hand, is to be a man possessing a wide commercial training, whose sole occupation will be to further the interests of the French trade generally in every possible way, by looking out for contracts, preparing the way for future business, and keeping manufacturers at home informed as to what is being done in his particular district. The post will, in fact, be a new, well-paid, and highly-specialised branch of the consular service. The taking part in international exhibitions and the organising of French exhibitions abroad are also recommended as a means of developing foreign trade, while in view of recent diplomatic events, M. Trouillot, the former Minister of Commerce, has pointed out the necessity of backing up this foreign trade expansion with a powerful army and navy. In discussing these methods of developing business the Paris Congress seems to have entirely overlooked the main difficulty manufacturers have to grapple with in foreign markets—that is, the price-cutting of their foreign competitors. Our French friends may proclaim the superiority of their products; but this does not prevent customers from giving a preference to cheap goods, especially when the seller is not exacting as to the means of payment, and has an agent on the spot who guarantees in a certain measure the maintenance of the installation supplied by his firm.

CHICAGO AND TYPHOID FEVER.

OUR readers will remember the typhoid fever scare which threatened to keep visitors away from Chicago during the Great Exhibition of 1893. There was every reason for apprehension. During the ten years 1881 to 1890 inclusive, the number of deaths from typhoid fever had fluctuated from 4·67 to 10·51 per 10,000, with an average of 6·86. In 1891 the number rose suddenly to 17·38 per 10,000, and though it fell in 1892 to 12·41, it was still far too high to be satisfactory. The figure 17·38 was, we believe, a higher death-rate from this cause than had been experienced in any large city in the world for many years. The wonder is that the deaths were so few, when it is considered what was being done. At the end of 1888 there were three sewers discharging into the lake. Subsequently and quickly the number was increased to 29. Meanwhile the city's water supply was being taken from the lake at distances varying from 1400ft. to two miles from the shore. There was every possible invitation to typhoid to come and stay. It is very doubtful, if the World's Fair had not been held in 1893, whether the steps which were taken would have been instituted. As it was, all the authorities strained every nerve to get the water intakes farther from the shore, and so to dispose of the sewage that it should not be delivered into the lake. The result was that during the Exhibition year the typhoid death-rate fell to 5·35, and has since fluctuated gradually downwards, as further sanitary improvements have been carried out. The great drainage canal was put into service in 1900, and though the rate was 4·41 in 1902, it has fallen ever since, and was for the first 147 days of this year as low as 1·21 per 10,000. It is inconceivable how such a state of affairs could have existed at such a period of history with a city like Chicago. At Pekin, perhaps, it might have been looked for; but Chicago! Perhaps it is due to the fostering care of the Board of Trade and the Local Government Board—whose restrictions, by the way, we are all inclined to grumble at at times—but certainly slow water filtration has been brought to a much higher development in this country than in America. Sand filtering plants are now gradually being adopted, and where they are being installed the work is being excellently carried out. There are, however, still many places where, at the most, a slight period of sedimentation is given, and, at times, not even that. The mechanical filter is still greatly favoured, but it is doubtful if it gives continuously results which are as good as those obtained with a properly-constructed and well-looked-after slow sand filter. The good work done by this type of filter is best appreciated by a consideration of the source of the bulk of London's water supply and of the comparative immunity from typhoid fever which we enjoy.

LOCOMOTIVE COAL CONTRACTS.

AFTER more than a month's deliberation the negotiations which have been going on between a limited section of South Yorkshire coalowners holding half-yearly contracts and the Midland and Great Northern Railway Companies has resulted in supplies for the next half year being contracted for at a reduction of 3d. per ton. It is known that the bulk of the railway contracts fall out at the end of the year, but the companies have so arranged that some of the smaller contracts should terminate at the end of the half year. The district collieries, some five or six in number, sent in tenders at the old rate, 8s. 3d. per ton, and expressed their determination to take no less for the best South Yorkshire hards. Certain Nottinghamshire and Derbyshire collieries holding like contracts, it is understood, sent in tenders at the old rate. Both railway companies from the first are said to have claimed a reduction, and in the case of the South Yorkshire collieries they firmly offered 8s. per ton. The coalowners held out for the old rate, but it is stated they were obliged to accept the offer, owing to Nottinghamshire and Derbyshire coalowners giving way. Although the contracts which fall out are only small compared with the vast tonnage which has to be replaced at the close of the year, the concession made will have an important bearing on the placing of the contracts at the close of the year. It is said that the Nottinghamshire and Derbyshire collieries are likely to play an important part in regard to future contracts, as some of the collieries are now working a very fair quality of steam coal. Some idea may be formed of the importance of the concession when it is stated that the locomotive coal expenditure for the last half of 1903 was for the Great Northern, £163,711; whilst the Midland coal bill for the same period amounted to £310,093.

LITERATURE.

A Treatise on Concrete, Plain and Reinforced. By FREDERICK W. TAYLOR, M.E., and SANFORD E. THOMPSON, S.B. Assoc. M. Am. Soc. C.E. First Edition. First Thousand. New York: John Wiley and Sons. London: Chapman and Hall, Limited. 1905.

THREE-QUARTERS of the present volume are devoted to "Concrete Plain," and the remainder to the same material reinforced. The former subject is treated exhaustively, from definitions, classifications, selection of ingredients, quantities, proportions, strength and composition, testing, voids, preparation of materials, and mixing, to final deposition. Each of these items occupies a chapter of its own, some of which are written by outside contributors. Several of these possess but a perfunctory interest for the trained engineer, but will be of use to those requiring information and direction in the more elementary procedure in laying concrete. We shall therefore pass on to the chapter, "Strength of Plain Concrete." The laws governing the strength of plain—that is, non-reinforced—concrete, have been known and recognised, and proved by the experiments of Grant nearly forty years ago. A formula has been deduced by the authors by which, knowing the exact quantities of the raw materials entering into a concrete of a given strength, it is possible to estimate the approximate strength of any other concrete mixed in different proportions of the same materials. Though the formula is simple and easy of application, it is surrounded by conditions so onerous that we doubt if it will prove of much practical utility. The stipulations prescribe that the "other concrete" must present itself "under similar conditions of manufacture, age, storage, and methods of testing." Admitting experimental crushing tests as a trustworthy basis, the safe working loads may be considered to range from one-third to one-tenth of the breaking weights. These limits are equivalent to 730 lb. to 220 lb. per square inch for a specimen of 1 : 2½ : 5 concrete at the age of one month.

In dealing with reinforced concrete beams, the straight line theory of distribution of stress, with the concrete taking no tension, has been adopted. To support this theory, and as a foundation for practical designing, the following five hypotheses are assumed:—(*a*) Conservation of plane sections. (*b*) Steel takes all tension. (*c*) No initial stresses in steel. (*d*) Perfect adhesion of concrete to steel. (*e*) Modulus of elasticity of concrete within usual limits of stress, is a constant. As considerable difference of opinion exists among good authorities respecting the truth, or even the approximate truth, of these hypotheses, it will be worth while to inquire a little more in detail concerning them. It should be added that unity of action of the two materials is indispensable. There is experimental evidence to demonstrate that the first assumption is practically correct. This view is corroborated by M. Considère, a French engineer of considerable repute, and the inventor of hooped concrete. While proving that the hypothesis was wrong in itself, he found that it furnished results of sufficient accuracy to calculate the bending moments, except in the near neighbourhood of heavy concentrated loads. Hypothesis (*b*) is not accepted as correct by all engineers, even though the design may be efficiently developed. The result of some recent experiments upon reinforced concrete beams, made by Mr. F. E. Turneaure, Assoc. M. Am. Soc. C.E., strengthens the opinion that the tensile strength of the concrete should be disregarded and considered as centred in the steel.* With respect to (*c*), the tests of M. Considère and other experts indicate that it is not accurate, but no serious error is introduced by it. Assumption (*d*) will stand, conditionally upon the proper distribution of the two materials, but designs frequently have not enough concrete below the steel. It must be kept in mind that the modulus of elasticity of concrete, which enters into the calculations, is a very uncertain quantity, and capable of varying with every variable quantity and quality belonging to this mode of construction. Professor Brik makes a very proper distinction between the modulus of elasticity and that of deformation. He considers that the latter, which is the lesser of the two by an amount corresponding to the permanent set, should be used in all cases. The statement made that the authors champion the assumption which makes the stress curve a right line is not of universal acceptance. Some regard it as a parabola, with its axis perpendicular to the direction of the applied forces, and the vertex on the extreme outer element of the concrete in compression. Others, while allowing the parabolic form of curve, maintain that the axis of it is on the neutral axis of the piece, and its own axis at right angles thereto. Another assumption is that the correct form is that of an empirical curve, derived from plotting the results of actual tests.

The chapters relating to the testing of pure cement, cement and mortar, and of concrete may be read with advantage. The "Vicat" needle apparatus used for this purpose is the improved instrument. In fact, the old needle, as devised by Vicat, consisted of nothing better than an ordinary darning needle filed square at one of its extremities, and loaded with a leaden weight of 10½ oz. The subject of concrete building construction, including floors, girders, walls, stairs, columns, and other cognate examples, are fully discussed, as well as tunnels, bridges, dams, reservoirs, and works of a more pretentious character. Some additional formulas, rather too complicated for insertion in the body of the volume, have been wisely relegated to the appendix. The book is generally of a useful and practical tendency, theory and mathematical calculations being introduced with commendable discretion. This volume of 500 pages will serve as an excellent reference and text-book for engineering students, and may be perused with profit by those more advanced in their knowledge of the subject.

* "Concrete and Concrete-Steel in the United States." By Edwin Thacher, M. Am. Soc. C.E. International Engineering Congress, St. Louis, Missouri. 1904.

LIEGE EXHIBITION.

750 HORSE-POWER SULZER-CARELS ENGINE.

THE Société Anonyme des Ateliers Carels Frères, of Ghent, shows in running order a dynamo made by the Société Anonyme des Ateliers de Constructions Electriques à Charleroi, driven directly by a 750 horse-power horizontal compound Sulzer-Carels condensing engine, making 110 revolutions per minute with steam at 10 atmospheres, or 147 lb. per square inch. A drawing of this engine appears on page 655. The diameter of the high-pressure cylinder is 575 mm. (= 23in.), and of the low-pressure cylinder 900 mm. (= 35½in.), while the stroke is 950 mm. (= 37½in.). Both cylinders are steam-jacketed in the usual way, but only one cover, that at the front, appears to receive steam.

Steam from the boiler passes through the regulator valve into the jacket of the high-pressure cylinder, whence it is distributed by balanced double-seated drop valves. The two admission and the two exhaust valves of each cylinder, all of them spring-loaded, are opened by rods actuated by excentrics, one for each pair of admission and exhaust valves. The cut-off for the high-pressure cylinder is regulated by the governor; but that for the low-pressure cylinder is invariable, being fixed at 56·6 per cent. of the stroke for the normal speed of 110 revolutions. If it be desired to increase or reduce the speed, this may be done by shifting the governor counterweight on its lever by means of a screw and hand wheel. The horizontal shaft carrying the four excentrics and also driving the governor is connected by mitre gear with the main shaft in the ordinary manner. The Porter governor sets the cut-off at an earlier or later period of the stroke by altering the position of a special releasing catch, seen in the end view of the small cylinder, the admission being variable between zero and 75 per cent. As the valves are balanced, they offer very little resistance to motion, and their opening and closing is effected without shock. As the slight resistance of the valve gear in no wise impairs the sensitiveness of the governor, the running of the engine is remarkably regular even with great variations of load.

The exhaust from the high-pressure cylinder is led by a copper pipe to the middle of the large cylinder, and passes into the jacket before being distributed by double-seated admission and exhaust valves, similar to those of the small cylinder. The exhaust valves of this cylinder, like those on the high-pressure end, are actuated by the same excentrics as are the admission valves; and this is effected by means of a curved lever rubbing against another, giving a smooth progressive lift. The gear is very little different to the ordinary Sulzer gear. The exhaust from the large cylinder is led by a large pipe, also of copper, to the jet condenser in the foundations, the air-pump of which is worked by a bell-crank lever and connecting-rod from a crank on the main shaft, as may be seen in the vertical longitudinal section.

This view also shows, at the end of the condenser opposite the bell-crank, an arrangement of two sprocket wheels, connected by pitch-chain, for shutting off steam from the condenser and allowing it to escape into the open air, in the event of any slight repairs being required to the air pump or condenser while the engine is working. The upper of the two wheels is turned by a winch

handle, and the latter revolves in a valve chamber without lateral displacement. The rotary motion causes the threaded spindle of a disc valve, with conical face on either side, to leave the seat where it shuts off communication from the air and come down upon the other, so as to close communication with the condenser.

One end of the engine frame, resting upon the masonry foundations, is bored to receive the large cylinder casing which is bolted to it, thus ensuring perfect truth and also great rigidity. The two cylinders are connected by a box stay, cast in two parts, with a vertical joint, to permit easy unshipping of the inside cylinder covers and access to the pistons. By this arrangement all the parts can be overhauled as easily as in a single-cylinder engine; and the small cylinder, in which variations of temperature are greatest, can expand and contract freely. Cast with the casings of the cylinders are the feet shown in the cross sections, one for the large and two for the small cylinder, bolted down to plates bedded in the foundations; and in the case of the small cylinder, the nuts, after being screwed home, are slacked for part of a turn, while the bolt holes are made oval, so as to permit a slight horizontal movement corresponding with expansion and contraction.

The piston-rod for the two cylinders is 12 cm. (= 4$\frac{23}{32}$in.) in diameter; and its free end is turned down to a smaller diameter to receive the high-pressure piston. The latter is secured by a steel nut, made in one piece, with a tube of the same external diameter as the piston-rod passing through the back cover, and being protected by a casing. This continuation of the piston-rod is supported outside by a guide, which slightly yields to any variation from a straight line. Instead of brasses, the pin of the crosshead is carried by cast steel bearings lined with white metal, and the wedge piece for taking up wear is also made of cast steel.

The bearings of the crank shaft are lubricated automatically and continuously, while the lubrication of the cylinders is effected by a small double-acting force pump, worked by the engine. All the other parts in motion are provided with sight-feed lubricators, accessible while the engine is running. The main plummer-blocks and the lower slide of the crosshead are kept cool by water, led up by a small pipe branched off from that of conveying the injection water for the condenser, which is under a certain pressure, while the circulation is also favoured by the vacuum of the condenser on one side and the pressure of the exhaust steam on the other.

THE ROYAL SOCIETY'S CONVERSAZIONE.

On Friday evening the Royal Society gave at Burlington House the second, or ladies', conversazione of the season. Sir William and Lady Huggins received the guests, among whom were:—Lord Strathcona, Lord Reay, Sir Trevor and Lady Lawrence, Sir William and Lady White, Sir Arthur and Lady Rücker, Sir Joseph Swan, Sir William Ramsay, Sir William Abney, Sir Norman Lockyer, Sir Henry Roscoe, Sir John I. Thornycroft, Sir William Crookes, Sir Howard and Lady Grubb, Sir James Crichton-Browne, and Sir Henry Trueman Wood.

As usual, there were a large number of interesting exhibits. Many of these are the same as those which were shown at the first conversaziones of the season, and as we mentioned them then, we need not refer to them again. There were, however, a number of novelties, and though these, in most cases, had but little reference to engineering, yet they were all of scientific value, and a short account of some of them will, doubtless, be of interest to our readers. It will be best, perhaps, if we follow our usual custom and deal with the exhibits in the order in which they appear in the catalogue. Mr. G. T. Beilby showed a specimen of the metal sodium prepared to show its true colour and lustre by Dr. Thomas Ewan. It was made by melting the metal in vacuuo in one vessel and running the clean, bright part of the liquid into another communicating vessel which had been freed from condensed air or moisture by heating during exhaustion. After solidification of a crystalline crust on the glass the surplus liquid was run back into the first vessel and the specimen globe was sealed off. Messrs. R. and J. Beck, Limited, exhibited a small camera for taking direct photographs in connection with a microscope. It consisted of a short tube carrying a projecting lens and a photographic plate. It is placed over the eyepiece of the microscope, focussed in the ordinary manner and exposed by means of a shutter in front of the projecting lens. The "Osmi" incandescent lamp of the General Electric Company was on view. This lamp in appearance is very similar to the ordinary electric incandescent lamp, but in place of carbon the filament is made from the metal osmium. The advantages claimed for this lamp are:—High fusing point, white light, higher electrical efficiency, longer life, saving of current, less heat. The blackening of bulbs is said to be inappreciable. The consumption of current with an ordinary carbon filament lamp is not infrequently 3·5 to 4 watts per candle-power. The consumption of current with Osmi lamp is given as being 1·5 watts per candle-power. The Cambridge Scientific Instrument Company exhibited the Fery radiation pyrometer. In this instrument the image of a hot body or of the inspection hole in a furnace wall is focussed upon a thermo-couple connected to a direct reading galvanometer on the centigrade scale. The instrument, as shown at work, was sighted upon a disc of hot iron within an electrical resistance furnace.

Mr. C. Baker showed the Ettles-Curties ophthalmometer and ophthalmic microscope. The ophthalmometer is an instrument for measuring the radius of curvature of the cornea, and consequently of ascertaining the dioptric value of the refracting medium bounded by that curvature. The instrument consists of an attachment by which the patient's head is steadied, and a telescope with a Wollaston prism for observing the images of the "mires." The latter are carried on an arc graduated in terms of dioptres and radius of curvature, and prismatic steel bars provide a steady movement by rack and pinion to the adjustable parts. The whole is mounted on a telescopic floor standard, which contains a plunger actuated by a spiral spring; by slight pressure this can be pushed down to the level of the patient's eye and clamped. The ophthalmometer can be detached and a microscope provided with electric illumination substituted.

The exhibit of Messrs. Siemens Brothers and Co., Limited, included some specimens of the metal tantalum in the form of small blocks of more or less purity; also of sheet and of metallic powder, and of specimens of wire of various thicknesses. There was also a series of tantalum glow lamps, requiring 110 volts and ·34 ampères to give a light of 25 candles. This works out to a consumption of about 1½ watts per candle-power.

A number of stereoscopic photographs of the "Cullinan" diamond, of diamonds in the Diamond Office, Kimberley, and other large diamonds were shown in a revolving stereoscope by Sir William Crookes.

Sir Norman Lockyer, besides showing some photographs of British stone circles and some spectro-heliograph photographs, had prepared some instructive curves representing the changes in the flow of the Thames as compared with the variations of British barometric pressure and rainfall. It was interesting to note the correspondence between the various sets of curves.

A curious series of experiments have been carried out by Dr. W. J. Russell. He has taken a number of specimens of wood of different kinds and made two distinct series of photographs of these after they have been smoothed. In one set the wood was actually laid in contact with the sensitive plate and kept there in the dark for periods of from one to eighteen hours at a temperature of 55 deg. Cent. In the other series photographs were taken in the ordinary way. The results shown were curious, and proved distinctly that the wood had powers of absorbing and giving out actinic rays, and that these powers were by no means constant over a given surface of the wood. They followed to a large extent the grain markings, the "dark" photographs being frequently opposite in colour value to those of the same object taken in the ordinary way.

Professor W. F. Barrett exhibited the entoptoscope, of new form of ophthalmoscope, devised by him for the self-examination of the eye by means of pinhole vision. When an illuminated and fine pinhole in a sheet of metal is held near the eye sharp shadows of any opaque, or semi-opaque, object in the path of the rays within the eyeball are thrown on the retina. By this means the growth of cataract from its earliest stages can be traced. By two closely adjacent pinholes in the revolving diaphragm, and by using the transparent scale in the eyepiece, the exact magnitude and distance from the retina of the opacity can be determined.

Sir William Preece showed a new and ingenious sun-dial, designed by Professor Albert Crehore, for telling standard time. In this apparatus, which was a beautifully executed bronze casting, the gnomon of the common form of dial is abandoned, and the shadow of a small bead fixed on a wire is cast on the interior of a true cylindrical surface, upon which figure of eight curves are drawn marking standard noon for each day of the year. The cylindrical surface is inclined so that its axis, upon which the bead is fixed, is parallel to that of the earth. It thus represents the latitude of the place. The shadow of the bead travels across the cylindrical surface parallel to or on one of the circles drawn thereon. These circles represent days of the months. Each hour described in the circle is always of the same length, and a scale of minutes engraved on the cylinder enables true mean time to be read off directly to a few seconds.

As usual there were lantern slide demonstrations during the evening. Dr. Edward A. Wilson again showed his interesting and beautifully prepared series of slides relating to the life and work done on board the Discovery during the years 1902 to 1904. Sir W. de W. Abney showed a wonderful series of lantern slides made by the three-colour process. The slides were prepared by means of prints from three negatives for each subject shown. Each of the three negatives had been taken through an appropriate coloured medium, and the three transparent prints were projected on a screen with screens of the correct colour behind them. The process and apparatus employed is based on that of Mr. Ives. This demonstration was in every way successful.

DOCKYARD NOTES.

All the new armoured cruisers of this year's naval programme—that is to say, the four improved Minotaurs—will be fitted with turbines, and 25 knots is the speed hoped for.

The contract for the "experimental" 36-knot destroyer has been secured by Messrs. Thornycroft. She will have turbine engines. The five 33-knot destroyers will be built by Messrs. Beardmore, and, according to report, will be of over 1200 tons displacement. These are the "ocean-going" destroyers. The horse-power will be from 15,000 to 18,000.

The sister to the Italian cruiser St. Giorgio will be named St. Marco. Two sisters, Amalfi and Pisa, are in the projected stage.

The Swedish torpedo boat, Plejad, has been launched at Havre. She is a Normand boat, and designed for 26-knot speed.

The remainder of the German Deutschland class are now in hand—"Q" at the Germania Yard, and "R" at Schichau's. A large cruiser "D" is in hand at the Blohm and Voss Yard at Hamburg.

Instead of the 18 knots expected of her, the German battleship, Preussen, of the Braunschweig class, reached only 17·2 knots.

The usual new Spanish programme is up for consideration again. This time it consists of eight battleships of 14,000 tons each, five armoured cruisers of 10,000 tons, and a variety of small craft. The construction is "to be spread over a period of some years." Meanwhile, the last of the Spanish duplicates of our Orlando class is nearing completion, and should be in commission within five years from now if all goes well and the normal rate of construction is maintained.

The actual number of new Russian armoured cruisers in hand is variously reported, but actually appears to be three. These are named Bayan, Pallada, and Admiral Makaroff.

All the big ships of this year's programme are to be without rams. They will probably make better weather in consequence, but the impression is common in the service that the ram improves speed.

The constitution of the German fleet for the forthcoming manœuvres is as follows:—1st Squadron: Wittelsbach, Wetten, Lothringen, Mecklenburg, Kaiser Karl der Grosse, Kaiser Wilhelm II., and Kaiser Wilhelm der Grosse. 2nd Squadron: Kaiser Friedrich III., Braunschweig, Brandenburg, Wörth, Weissemburg, and Elsass. Cruisers: Friedrich Karl, Prinz Heinrich, Amazone, Arkona, Ariadne, Frauenlob, Medusa, and Hamburg. The composition of the battle squadrons does not indicate much respect for homogeneous divisions.

BOOKS RECEIVED.

Gas Engine Design. By Charles Edward Lucke. London: Archibald Constable and Co., Ld. Price 12s. 6d. net.

Die Selbstkostenberechnung Industrieller Betriebe. By Friedrich Letfner. Frankfurt-a-M.: T. D. Sauerländers.

Robert Dick, Baker of Thurso, Geologist and Botanist. By Samuel Smiles, LL.D. London: John Murray. Price 3s. 6d.

The Geology of the North Staffordshire Coalfields. By Walcot Gibson, B.Sc., F.G.S. London: E. Stanford. Price 6s.

Model Sailing Yachts: How to Build, Rig, and Sail them. By Percival Marshall, A.M.I.M.E. London: Percival Marshall and Co. Price 1s.

Official Illustrated Guide List, issued by the London and South-Western Railway Company, of Hotels, Boarding-houses, Seaside and Farmhouse Apartments.

City and Guilds of London Institute, Department of Technology: Programme for the Session, 1905-6. London: John Murray, Albemarle-street. Price 9d. net.

L'Encyclopédie Scientifique des Aides-Mémoire le Vanadium. Par Mons. Nicolardot, Capitaine d'Artillerie. Paris: Gauthier-Villars, Quai des Grands-Augustins, 55. Price 2f. 50c.

L'Encyclopédie Scientifique des Aides-Mémoire l'Industrie de l'Or. Par Mons. L.-M. Granderya, Préparateur à l'Univereité de Nancy. Paris: Gauthier-Villars, Quai des Grands-Augustins, 55.

Revue de l'Ingénieur et Index Technique. Publication Mensuelle. Vol. VI. No. 1. April, 1905. Brussels Association de la Presse Technique. Musées Royaux, Rue du Musée 1. Price 2f. 50c.

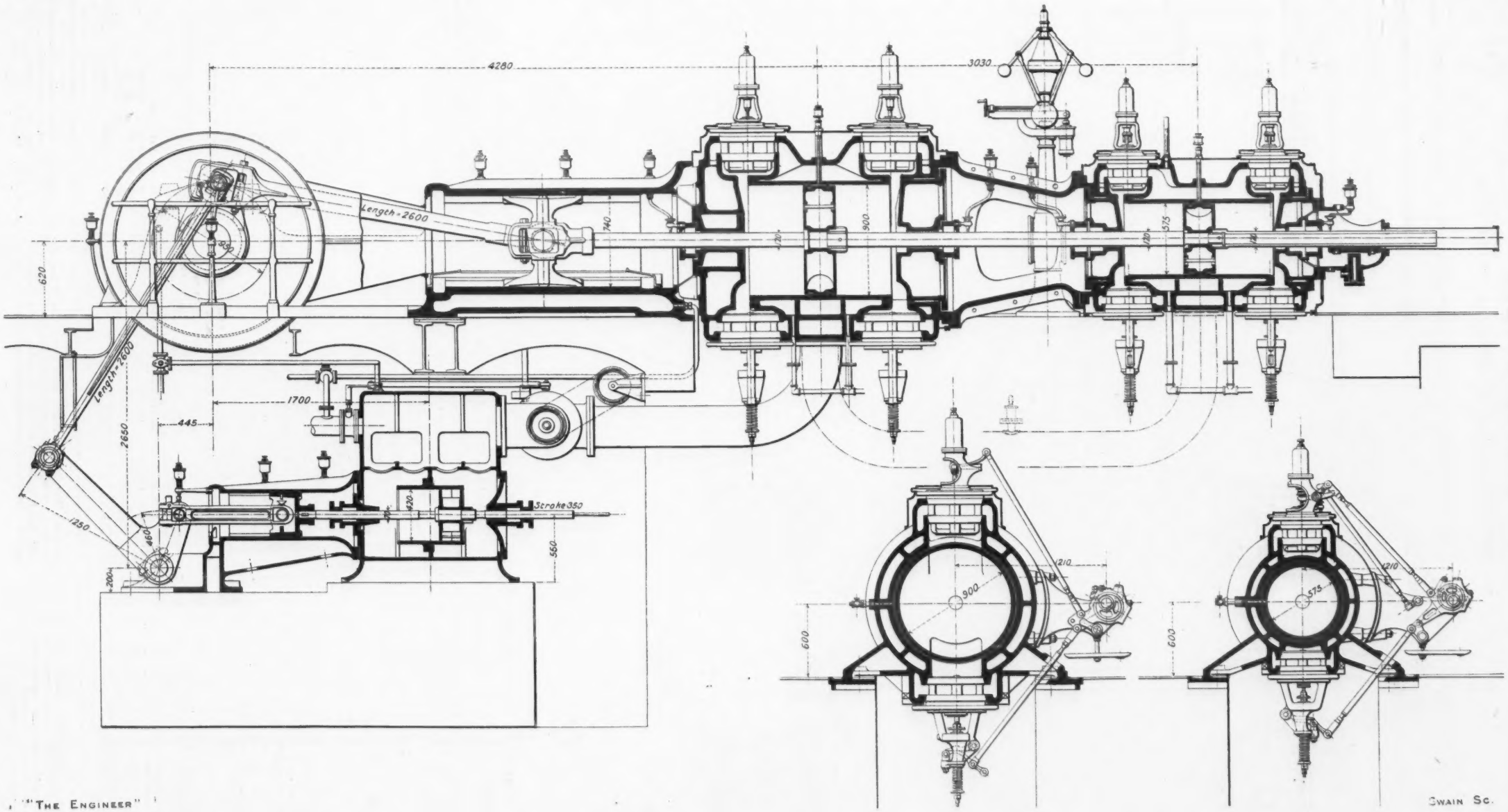
Society of Engineers.—A highly interesting visit was made by the President, Mr. Nicholas J. West, and members of the Society of Engineers, on Wednesday, June 28th, 1905, to the Lots-road Electric Power Generating Station of the Underground Electric Railways Company, of London, by kind permission of Mr. James R. Chapman, the company's chief engineer.

Royal Meteorological Society.—The final meeting of the present session was held on Wednesday afternoon, June 21st, at the Society's rooms, 70, Victoria-street, Westminster, Mr. Richard Bentley, F.S.A., president, in the chair. Mr. G. C. Simpson read a paper on the "Normal Electrical Phenomena of the Atmosphere." In no branch of physics has the discovery of "ions," "electrons," and "radio-activity" produced a greater revolution than in that devoted to atmospheric electricity. In this paper the author endeavoured to state the chief line along which during the last few years investigations have been made, and the conclusions arrived at, and also to point out some of the problems awaiting solution. The amount of radio-active emanation in the lower regions of the atmosphere is increased by all those meteorological conditions which tend to keep the air stagnant over the earth's surface. The meteorological conditions which either cause or often accompany stagnant air are calm, low temperature and high relative humidity, while on the contrary, high winds, high temperature, and low humidity generally accompany the mixing of large masses of air. This all agrees with the observed facts that the atmospheric radio-activity increases with falling temperature, rising humidity, and increasing wind strength. The author is of opinion that a solution of the problems of atmospheric electricity can only be expected from the results of extended measurements in the atmosphere itself, and from laboratory experiments directed towards the problem. A paper by Mr. G. P. Ferguson—"Two New Meteorological Instruments"—was, in the absence of the author, read by the Secretary. The instruments described were (1) automatic polar star light recorder, for recording the amount of cloudiness at night; and (2) the ombroscope, an instrument for determining the time and duration of rain. Both of these instruments are in use at the Blue Hill Observatory, Mass., U.S.A.

The Manufacturers' Association of Great Britain.—We have been sent a copy of a preliminary circular setting out the objects with which the Manufacturers' Association of Great Britain is being formed. Widely speaking, the aim of this association is to stimulate and expand British trade in colonial and foreign markets. The circular points out that at the present time Chambers of Commerce and Shipping, the consular service of this country, the Intelligence Department of the Board of Trade and other organisations, are all separately engaged in collecting information of value to the export trade, but such intelligence is scattered over a wide range, and is often presented in a diffused and uncommercial style. What, it is pointed out, is urgently needed is some means of rapidly co-ordinating all the news and placing it in a pointed and specific manner before every British firm to which it is likely to be of service. In addition to ascertaining what openings there are for trade, and the local conditions of colonial and foreign markets, it is equally important systematically to make known to buyers in those markets what British firms are capable of producing, and generally to give a correct impression of the enormous extent and progressive character of British manufacturing industries. The Manufacturers' Association is now being formed to create the machinery by which the foregoing and many other services can be rendered to British trade. The association intends to appoint correspondents in all parts of the world, whose business it shall be to report on openings for trade, and local changes and conditions within their respective spheres. The reports obtained will all be collated and distributed among those firms which it will most benefit. In addition to this the knowledge already in the possession of and to be collected by the Board of Trade and other Government offices, Chambers of Commerce, and other bodies is to be brought together, classified, and properly distributed. Another proposal is the compilation in the principal languages of the world of a trade index to British manufacturers, and its free distribution to Chambers of Commerce and to large merchants and others in colonial and foreign markets. As the association is to be of a national character, and thoroughly representative of the export manufacturing and trading interests of the country, it is claimed that it will speak with a weight which no single body now possesses when legislation affecting the export trade is being considered by Parliament and the country. Further information may be obtained from the secretary, the Manufacturing Association of Great Britain, Orchard House, 2 and 4, Great Smith-street, Westminster, S.W. The aims of the association appear to be worthy of the heartiest support of all our manufacturers.

750 HORSE-POWER TANDEM COMPOUND ENGINE—LIEGE EXHIBITION

(*For description see page* 654)

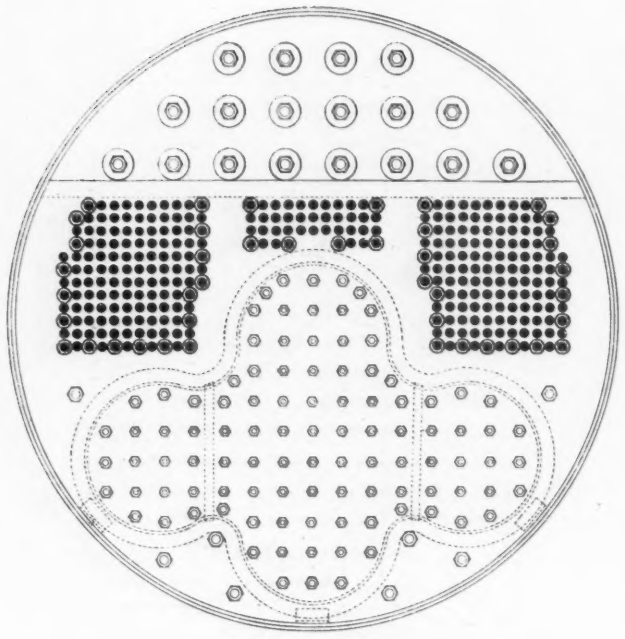


"THE ENGINEER"

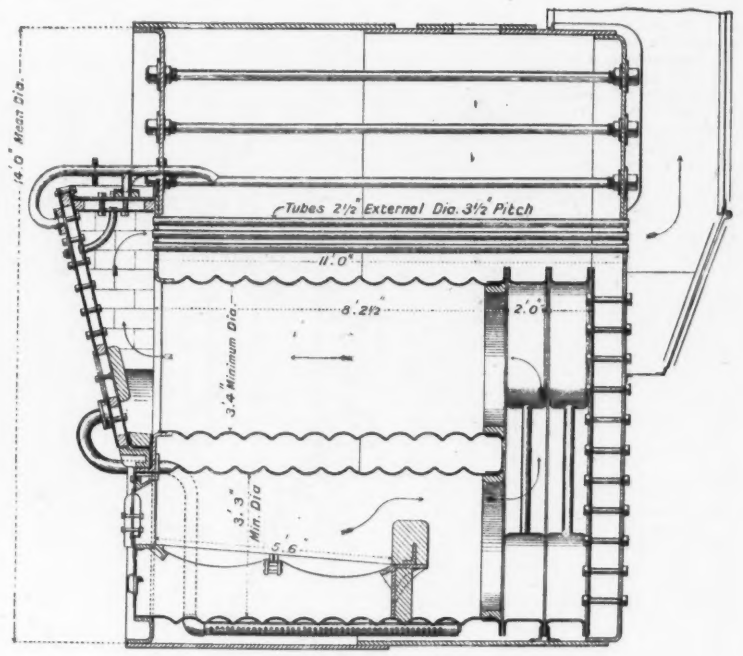
SWAIN SC.

MARINE BOILER

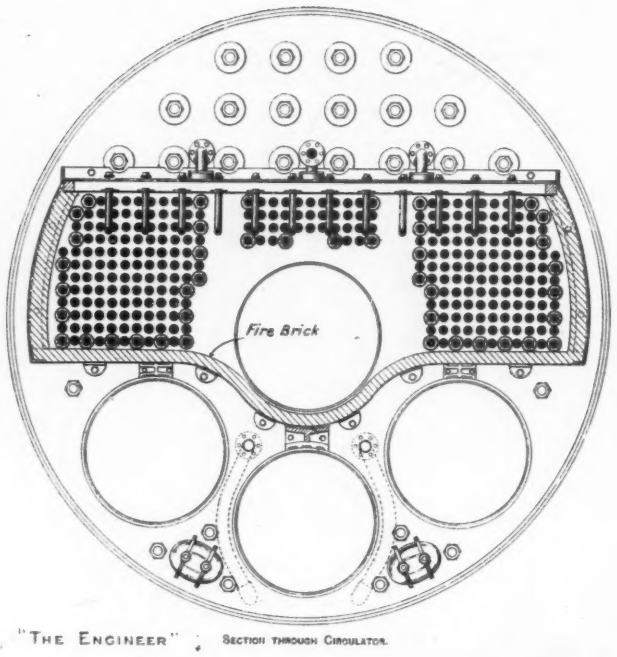
THE INGLIS BOILER SYNDICATE, LIMITED, GLASGOW, ENGINEERS



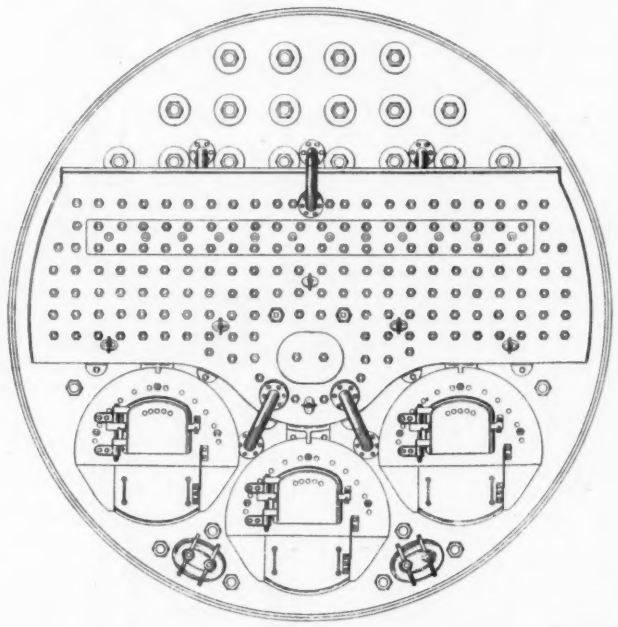
SECTION THROUGH SMOKE BOX.



LONGITUDINAL SECTION.



"THE ENGINEER" SECTION THROUGH CIRCULATOR.



FRONT ELEVATION.

SWAIN Sc

NEW MARINE TYPE BOILER.

THAT there is still room for improvement in the Scotch or tank marine boiler, and that invention aiming at such improvement has not been wholly killed by the favour to which the water-tube boiler has risen, is proved by the drawings which we give above, and the reports of tests which will be found below.

The present generator is a Scotch boiler—with a difference. The fuel is burnt in three flues, and the gases meet in a common combustion chamber at the back, but, instead of at once entering tubes, and passing to an uptake over the fire doors, they find themselves in a fourth flue of approximately the same diameter as the other three, where there is time and opportunity for all the gases to be thoroughly lighted. Thence they pass into still another chamber, where they spread out, complete their combustion, and pass through a large number of tubes into the uptake at the back. It will be seen at once that the superiority over an ordinary tank marine boiler lies in the great combustion chamber provided by the upper flue. There are two little peepholes at the back of the boiler, through which the condition of the gases in the chamber may be examined, and it has been observed that combustion is complete. Through these holes, too, a little air may be

Summary of Tests.

Tests by.	Particulars of boiler and conditions of tests.						Particulars of fuel and of firing.					Evaporation.				
	Heating surface.	Grate area	Ratio $\frac{H.S.}{G.A.}$	Steam pressure. Lbs. above atmosphere.	Air pressure in stokehold. Inches water gauge.	Duration of test.	Description.	Lbs. of coal burned per sq. ft. of grate per hour.	Heating power of coal. Lbs. of water per hour from and at 212 deg. Fah.	Heating power of coal. B.T.U.	Temperature of gases at root of chimney.	Actual lbs. of water evaporated per lb. coal as fired.	Equivalent evaporation from and at 212 deg. Fah.	Quality of steam.	Temperature of feed water.	Efficiency.
	sq. ft.	sq. ft.			in.	hrs.					deg. Fah.				deg. F	per cent.
Messrs. Burstall and Monkhouse, 14, Old Queen-street, London, S.W.	2593	53·5	1-48·5	175·35	½	8·45	Scotch	19·82	14·85	14,350	439	10·57	12·97	Dry	43	87·34
	—	—	—	178·6	1	8·43	,,	27·31	14·78	14,280	482	9·97	12·24	Moisture. ·0025	43	82·8
	—	—	—	183·5	3	7·98	,,	48·89	14·37	13,890	5.3	9·23	11·33	·0325	43	78·8
Professor Stanfield, M. Inst. C.E., Heriot-Watt College, Edinburgh	2620	55	1-47·6	180·8	¼	6·5	Welsh	20·10	14·5	14,030	457	10·34	12·70	Dry	42	87·58
	,,	,,	,,	180	1½	6·2	,,	33·20	14·5	14,080	475	9·61	11·82	,,	41·4	81·32
	,,	,,	,,	180·8	3	6·0	Scotch	48·00	14·06	13,600	524	8·90	10·94	,,	41·8	77·82
Messrs. John Brown and Co., Limited, Clydebank Engineering and Shipbuilding Works, Clydebank.	,,	,,	,,	185	2	6·0	Scotch	38·7	14·14	13,647	498	9·79	12·08	Dryness fraction	45	85·0
	,,	,,	,,	185	3	6·0	,,	48·9	14·14	13,647	593	9·23	11·40	·9909	45	80·2
Messrs. Denny and Co., Engineers and Shipbuilders, Dumbarton.	2530	55	1-46	181	⅛	6·3	Scotch	16·2	14·37	13,864	470	10·51	12·87	—	46	89·5
	,,	,,	,,	177	⅛	6·0	,,	19·0	14·37	13,864	410	10·35	12·70	—	44	88·4
	,,	,,	,,	180	1	6·2	,,	29·0	14·37	13,864	440	9·85	12·08	—	44	84·1
Messrs. The Fairfield Shipbuilding and Engineering Company, Limited, Govan.	2620	55	1-47·6	180	½	8·0	Scotch	19·2	14·44	13,952	445	10·35	12·45	Dryness fraction ·979	42·2	86·21

admitted if, as rarely happens, it is found advantageous. The fact that the products from all the flues meet freely here is beneficial, as it gives an opportunity for the cooler gases from a furnace which has just been fired to be heated and burnt by that from the other grates, and thus the emission of smoke is obviated. The deposit of ashes and dust takes place in this chamber, and there is consequently no birds-nesting of the tubes.

Besides combustion, circulation has also received attention. The front chamber is, it will be noticed, enclosed by a water wall in front and on top. The lower part is connected by two pipes with water circulators, which lie, one on each side, under the lowest flue. The upper part is provided with three pipes, which deliver near the water-line. The water is drawn thus from the coolest part of the boiler, heated, and delivered near the surface. The twelve small quadrant-shaped pipes which will be noticed have been introduced to join the top of the upright with the horizontal wall, and may be regarded as constructional. Plugs are provided for cleaning them, and a manhole through the front walls permits ingress to the combustion chamber. The tubes are all got at through a door at the bottom of the uptake.

The shape of the back combustion chamber will be seen in dotted lines in one of the end views. In order to give it the necessary strength, it is made in two parts—see longitudinal section—so that it is provided with a central circumferential flange. It has been passed by the surveyors as strong enough for the proposed pressures. Four vertical tubes join it across the narrowest part, their main object being to prevent the collection of deposit in the slight hollows at the shoulders. Examination has shown that the circulation up them is very active, and deposition is rendered impossible. The flat end is stayed in the manner shown. The whole weight of the flues and combustion chambers is taken by the front plate, and by three brackets, which may be seen dotted in one cross section.

Only one boiler of this kind has so far been made, but it has been tested by five separate authorities quite independently of each other, and with coal consumptions varying between 16·2 lb. per square foot of grate, with $\frac{1}{16}$in. of air pressure, up to nearly 50 lb. of coal, with 3in. of air pressure. A summary of the tests in tabular form is given below, with the general dimensions. It will be seen at once that the thermal efficiency of the boiler is very high, as much, according to Messrs. Denny and Co.'s trial, as 89·5 per cent. The tests were all of good duration; stoking was wholly by hand, and smoke only appeared for a short time immediately after firing, and only rarely then. The quality of the steam was good, being, according to Messrs. Burstall and Monkhouse, "to all intents and purposes absolutely dry." The boiler, it will be seen, appears to stand forcing very well, having a high efficiency even at a consumption of 50 lb. per square foot.

In reply to an inquiry as to the weight of the boiler, we have received the following information from the makers:—"Estimated weight of boiler complete to root of funnel with circulator"—that is the water wall over front combustion chamber—"internal and external pipes for same, mounting brickwork, &c., but excluding all auxiliary machinery in stokehold and funnel, and taking the water—hot—at the working level 7in. above tubes, 62½ tons. Allowing an extra 6½ tons for boiler weights as excluded in above, taking, say, an installation of eight boilers, total weight would be about 69 tons. This would give 443 lb. of steam per ton of stokehold weights, and on the basis of one of Messrs. John Brown and Co.'s trials, where 30,504 lb. of water were evaporated per hour from and at 212 deg. Fah." It remains only to add that the boiler was built by the Inglis Boiler Syndicate, Limited, of 83, Renfield-street, Glasgow.

Particulars of Boiler.

Working pressure in lbs. per sq. in.		180
Total number of tubes		309
Total tube surface	in sq. ft.	2224
Total flue surface	"	206
Front tube-plate surface	"	25
Total water-chamber surface	"	65
Total heating surface	"	2630
Area of firegrate	"	55
Area through tubes	"	7·4

Ratios.

Heating surface to firegrate	47·6
Firegrate to area through tubes	7·43

RESERVOIR IN THE SIHL VALLEY.

THE construction of a reservoir dam in the valley of the river Sihl, in Switzerland, is now under consideration. This reservoir, from the point of view of the quantity of water it will impound, is far in advance of all other examples in Europe. It will contain 3388·8 million cubic feet, whereas the present largest reservoir on the Continent, situated at Urft, near Aix-la-Chapelle, which is approaching completion, has a capacity of only 1606·15 millions. For the sake of comparison, it may be stated that the example at Gileppe holds 423·6 millions, or exactly one-eighth of the contents of the projected Swiss undertaking. A few particulars of the new Helvetic scheme are worth alluding to.

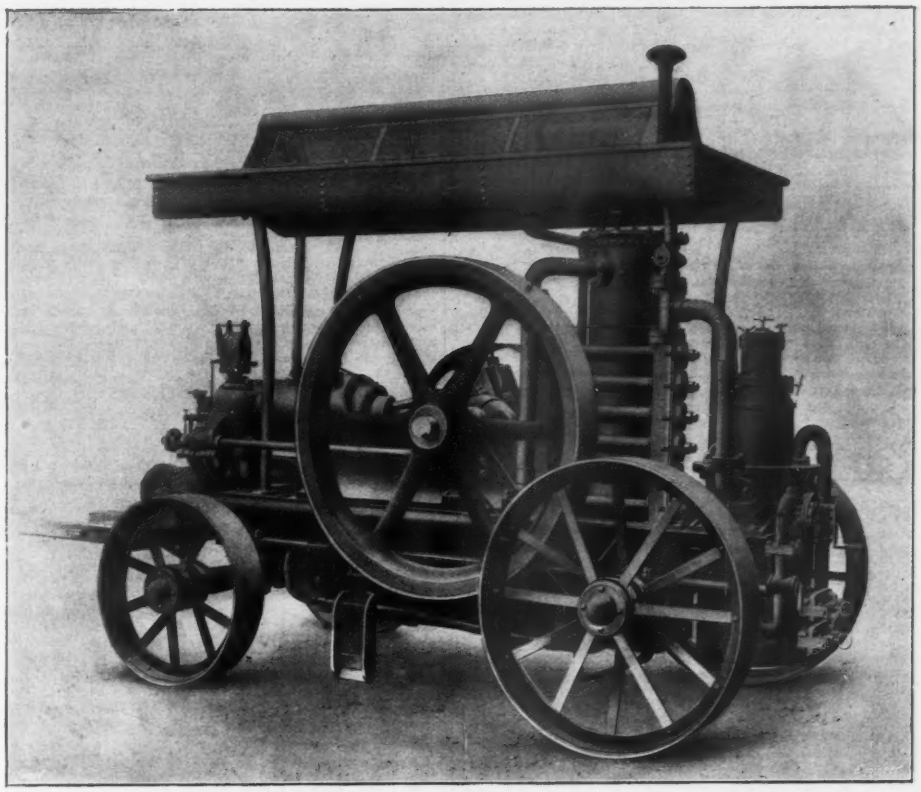
The length of the lake which will be created by the proposed dam will be 5¾ miles, and the width 1¼, giving a calculated area of 4608 acres. Its mean depth is put at 46ft. It is fortunate that the natural features of the valley of the Sihl are very favourable for the building of an engineering work of this description. This advantage is mainly due to the gradual narrowing of the site at the northern end of the valley. The length of the dam wall proper will be 140ft. at the base, 337ft. at the top, and 79ft. in height up to the level of the coping of the parapet. Owing to the foundation being of solid rock, not more than 26,000 cubic yards of stonework will be required. The dam will virtually be solidly embedded at the extremities in the walls forming the gorge of the river.

A pair of circular tunnels, equal to about a mile and seven-eighths in length, will conduct the water from the right bank of the lake to a series of conduits to supply the installation to be erected near Zurich, a total fall of 1855ft. The hydrographical basin of the reservoir is placed at a mean height of 4200ft., has an area of 62 square miles, and will give a net mean yield of 1422 gallons per second. An aqueduct 1150 yards long, consisting of eighty-three arches of masonry, and one span of steel, forms part of the scheme, to which may be added a couple of steel bridges. The cost is estimated at half a million, allotted as follows:—

Construction of the dam	£20,000
Purchase of land and compensation	£320,000
Bridges and roads	£100,000
Auxiliary and minor works	£60,000
Total	£500,000

PORTABLE GAS PRODUCER AND ENGINE

TANGYES LIMITED, BIRMINGHAM, ENGINEERS



PORTABLE SUCTION GAS PRODUCER AND ENGINE.

As the suction gas producer has proved such a great success in conjunction with fixed types of gas engines, Messrs. Tangye have conceived the idea of producing a portable combination of gas producer and engine with the object of enabling those requiring power which has to be moved from place to place to take advantage of the great fuel economy obtained by the use of a suction gas producer. The illustration given above shows a 12½ brake horse-power combined producer and gas engine. These have been arranged so as to keep the centre of gravity as low as possible, the whole being bolted to, and carried on, a steel girder frame mounted on four large travelling wheels. The gas producer is exactly similar to the usual fixed type made by this firm, with the exception that there is an additional air cooler, consisting of a number of tubes through which the gas from the generator passes, and in which it is lowered in temperature before entering the coke scrubber. This arrangement of air cooler reduces the amount of water required to be run through the coke scrubber. The generator is arranged at one end of the steel girder frame, thus enabling it to be readily charged with fuel, and the ashes, &c., to be removed from the fire grate and ash-box with a minimum amount of trouble. A tank of large capacity for holding the cooling water is carried on the girder frame, the water being forced through the jacket of the cylinder by means of a circulating pump, and then on to a canopy fixed at a convenient distance above the engine, having a perforated inclined surface, over which the water runs to be cooled by the atmosphere before returning to the tank. A small quantity of water from the canopy is allowed to flow into the coke scrubber, so as to keep the coke moist, and more thoroughly to cleanse the gas before passing to the engine. The total weight of the machine when loaded is approximately five tons.

AN INVESTIGATION TO DETERMINE THE EFFECTS OF STEAM-JACKETING UPON THE EFFICIENCY OF A HORIZONTAL COMPOUND STEAM ENGINE.*

By Mr. A. L. MELLANBY, M.Sc., of the Municipal School of Technology, Manchester.

AT the present time there is much diversity of opinion as to whether steam-jacketing the cylinders of reciprocating steam engines has any considerable influence upon their economy. Much information has been collected by the committees† appointed by the Institution to inquire into the subject, and the results of many trials have been collected and tabulated by them. As the outcome of these and other investigations, opinion has become somewhat settled on the following lines:—(1) That jackets are useful for slow revolution, but not for quick revolution engines. (2) That jackets are useful for simple and compound engines, but that their efficiency is doubtful if they are applied to triple or quadruple-expansion engines.

It has long been obvious that there was considerable room for further experimental research upon this subject. The author, therefore, determined to take advantage of the opportunity which he had of carrying out tests upon the experimental engine at the Manchester School of Technology, to see whether some definite knowledge upon this important point could not be obtained.

In most of the tests that have been published it has been the custom to run a trial on any available engine that was fitted with jackets, and to find out the water used per indicated horse-power per hour. This water would include the amount that entered the cylinder and the amount that was condensed in the jackets. Another trial would then be made with the jackets shut off, and the consumption per indicated horse-power per hour again measured. In some cases it has happened that the jacket steam has had the effect of reducing the engine feed or increasing the horse-power, and so improving the economy. In other cases it has happened that any reduced engine feed or increased horse-power has been more than counterbalanced by the extra steam used in the jackets. In the majority of the experiments published the jacketed and unjacketed trials have been run at the same load, and no attempt has been made to find the best conditions for either case. The chief reason for this has been that the engines experimented upon were in actual service, and their load was fixed by the amount of work they had to do, and not with regard to their best performance. Comparisons from such trials are of little scientific value, as it might easily happen if an engine were working at its most economical load for the jacketed conditions, the same load would not be the most suitable when the jackets were off. A certain amount of work has been done upon the experimental engines in colleges and technical schools, but this work has not had much effect upon current practice. In most cases the engines are so small that manufacturers have not sufficient confidence in their results to apply them to the design of large commercial engines. Also few systematic series of trials have been published.

After devoting considerable thought to the matter the writer determined upon the following scheme of experiments. To run a

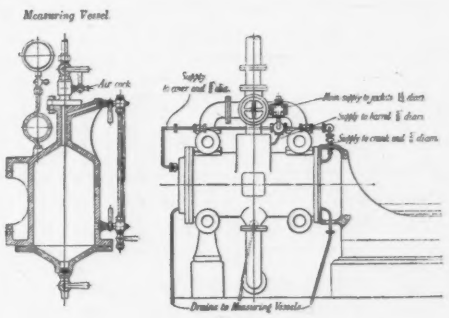

Measuring Vessel
Air cock
Supply to cover and T-pipe
Main supply to jackets ¾ diam.
Supply to barrel ¾ diam.
Supply to crank end ½ diam.
Drains to Measuring Vessels

FIG 1.

series of trials at the same boiler pressure, revolutions, and vacuum with different points of cut-off in the high-pressure cylinder. At each point of cut-off to run five trials—(1) With both cylinders unjacketed; (2) with the ends of the high-pressure cylinder jacketed; (3) with the ends and barrel of the high-pressure cylinder jacketed; (4) with the ends and barrel of the high-pressure and the ends of the low-pressure cylinder jacketed; (5) with the ends and barrels of both high and low-pressure cylinders jacketed. It will be seen that this gives five series of trials with various grades of expansion, and, if the range of expansion be sufficient, curves may be constructed which will allow us to determine the most economical number of expansions, and the consumption at that point for each series. From these curves the effect that jacketing has upon the economy can at once be determined, and the most efficient trials of the five series compared with one another. It seemed desirable that an attempt should be made not only to find out whether jacketing was efficient, but the reason for any efficiency it might have. Until the paper on "Cylinder Condensation" read before the Institution of Civil Engineers in 1897 by Messrs. Callendar and Nicolson, it had been the generally accepted opinion that any reduced steam consumption with steam-jacketing would be altogether due to reduced initial condensation. Messrs. Callendar and Nicolson, however, pointed out that initial condensation in steam engines was much less than had hitherto been suspected, and that a considerable portion of the "missing quantity" or difference between the indicated and actual weight of the steam passing through the engine was due to valve leakage. So far as the author knows, no experimental evidence has been adduced to disprove the assertions of the above-named experi-

* The Institution of Mechanical Engineers.

† See Steam Jacket Research Committee's Reports: First Report. "Proceedings," 1380, page 708; Second Report, 1892, page 418; Third Report, 1894, page 535; and Steam Engine Research Committee's First Report, 1905, Part II.

menters. As he had carried out some of the valve leakage experiments mentioned in their paper, he determined to adopt their method of calculating the amount of condensation and of inferring the probable valve leakage. This will be referred to more fully later on.

Description of the engines.—The engines are of the horizontal compound side-by-side type, with high-pressure cylinder 11¼in. diameter, low-pressure cylinder 20in. diameter, and stroke 36in. The high-pressure cylinder is provided with Corliss valves and gear, and the low-pressure with slide valves and Meyer expansion plates. The ends and sides of the cylinders are steam-jacketed. The jacket steam for both cylinders comes direct from the main steam pipe without any intervening reducing valves, and there are separate supply pipes each with a shut-off valve leading to each end and each barrel jacket. Fig. 1 shows the arrangement of the jacket supply and drain pipes. In all the trials the steam pressure in the jackets was practically equal to that at the high-pressure stop valve. During the trials the condensed jacket steam passed into separate calibrated vessels, where it was measured and then discharged to waste. The condenser used in these trials was of ordinary surface type. The air pump was separately driven by an electric motor of variable speed, and after taking the condensed steam from the condenser, delivered it into calibrated cast iron measuring vessels.

The brake used was a flat iron tube passing round the fly-wheel. Cold water continually circulated through the tube to keep down the temperature. The load consisted of dead weights applied through levers, but this load was directly measured by the pressure in a diaphragm cylinder through which the actual pull was transmitted. The author, however, regrets that, when these trials were being carried out the gauge attached to the diaphragm cylinder had not been calibrated, so that it has not been found possible to give the brake horse-power of the engine. As the made, each set having a different point of cut-off in the high-pressure cylinder as follows:—

1st set with 8·1 total expansions.
2nd ,, 12·3 ,, ,,
3rd ,, 18 ,, ,,
4th ,, 25 ,, ,,

In each set there were five trials—with the exception of the fourth, which contained only three—one unjacketed and the others with various degrees of jacketing, as explained in a previous paragraph. The point of cut-off in the low-pressure cylinder remained fixed for the whole of the trials. This was in accordance with the work done by Professor Weighton and the author on the engines at the Durham College of Science, and the actual point of cut-off was fixed from the curves given in Professor Weighton's paper.*

The author would here express his regret that more trials were not made with a greater variety of points of cut-off. So many variables come into play in an engine trial that it is practically impossible to run one test under exactly similar conditions to another. If there are a large number of experimental points, errors due to these differences can be generally eliminated when the results are reduced to diagrammatic form, and several discrepancies which appear in the diagrams might not have been there if more experiments had been made. The work involved in the preparation of the paper has, however, been so enormous, since every calculation and indicator diagram had to be worked out by the author alone, that it would have been almost impossible to finish the investigation had more been added to it.

Results from the trials.—Table II. gives the chief readings and results from the trials, the most important of which have been plotted in Figs. 2, 3, 4, 5, and 6 (*post*). In these figures it will be seen that the base line taken is the total number of expansions—that is,

TABLE II.—*General Results of Trials.*

		25 expansions.			18 expansions.					12·3 expansions.					8·1 expansions.				
1	Number of trial	108	109	105	88	89	90	93	94	95	96	97	98	99	100	101	102	103	104
2	Date of trial	June 21, 1904	June 21, 1904	June 14, 1904	April 22, 1904	April 26, 1904	April 26, 1904	May 3, 1904	May 3, 1904	May 10, 1904	May 10, 1904	May 10, 1904	May 17, 1904	May 17, 1904	May 31, 1904	May 31, 1904	June 7, 1904	June 7, 1904	June 14, 1904
3	Duration of trial	60 min.	60 min.	60 min.	60 min.	60 min.	55 min.	60 min.	50 min.	50 min.	50 min.	55 min.	60 min.	60 min.	60 min.	60 min.	60 min.	60 min.	55 min.
4	Steam pipe pressure, lb. abs.	166	166	165	161	163	165	163	163	160	160	160	165	163	161	164	158	161	—
5	Steam pipe temperature, deg. Fah.	365·5	365·2	366·7	364	366	366·5	365·2	365·0	363·5	363·8	363·3	365·4	365·3	364·5	365·7	363·8	364	364·2
6	H.P. exhaust pressure, lb. abs.	18·2	16·6	—	22·6	22·0	21·4	25	26	26·4	25·6	25·2	29·4	31·3	33·3	33·3	31·8	35·0	—
7	H.P. exhaust temperature, deg. Fah.	219	214·4	235	—	230	228	236	239	241	239	238	248·3	252	257	256·5	254	257·5	268
8	L.P. exhaust pressure, lb. abs.	3·1	3·1	—	—	2·75	2·75	2·7	2·7	2·7	2·7	2·7	2·9	2·9	2·9	2·9	3·1	3·1	—
9	L.P. exhaust temperature, deg. Fah.	135	135·6	141	—	133	129	132·5	133·7	132	132	132	135·3	137·5	137	137	138·6	140·0	142·5
10	Vacuum, inches of mercury	25·2	25·2	24·7	24·6	25·2	25·2	24·8	24·9	24·8	24·8	24·8	24·8	24·8	24·8	24·8	24·9	24·9	24·7
11	Barometer, inches of mercury	30·23	30·23	29·7	29·6	30·2	30·2	29·9	29·9	29·8	29·8	29·8	29·76	29·76	29·81	29·81	30·16	30·16	29·7
12	Air pump discharge during trial	1603	1503	1458	1757	1735	1505	1686	1397	1820	1715	1815	1967	1955	2757	2672	2557	2580	2365
13	Air pump discharge per hour	1603	1503	1458	1757	1735	1642	1686	1676	2184	2058	1910	1967	1955	2757	2672	2557	2580	2580
14	Steam condensed in L.P. steam chest	163	129	99	156	145	110	171	139	65	93	86	150	148	132	122	135	145	160
15	,, ,, H.P. cover jackets	Off	66	46	Off	59	55	39	36 (hour)	Off	47	42	39	38	Off	48	41	47	46 (hour)
16	,, ,, H.P. barrel jackets	Off	Off	51	Off	Off	54	56	52 (hour)	Off	Off	43	43	38	Off	Off	49	36	35 (hour)
17	,, ,, L.P. cover jackets	Off	Off	63	Off	Off	Off	30	41 (hour)	Off	Off	Off	89	108	Off	Off	Off	110	76 (hour)
18	,, ,, L.P. barrel jackets	Off	Off	75	Off	Off	Off	Off	60 (hour)	Off	Off	Off	Off	87	Off	Off	Off	Off	98 (hour)
19	Total steam used during trial	1603	1569	1603	1757	1794	1614	1811	—	1820	1762	1900	2188	2226	2757	2720	2647	2773	—
20	,, steam used per hour	1603	1569	1603	1757	1794	1762	1811	1865	2184	2114	2073	2138	2226	2757	2720	2647	2773	2245
21	,, revolutions during trial	3544	3563	3510	3521	3544	3214	3506	2977	3007	3007	3356	3519	3519	3583	3573	3503	3555	3283
22	Average revolutions per minute	59·1	59·4	58·5	58·7	59·1	58·4	59·9	59·5	60·1	60·1	61·0	58·6	58·6	59·7	59·5	58·4	59·2	59·7
23	Mean pressure in H.P. cylinder, lb. per sq. in.	50·0	50·0	47·0	54·4	56·5	59·0	55·0	52·5	66·0	67·0	67·5	64·2	62·0	79·0	78·0	77·5	74·0	70·0
24	,, ,, L.P. cylinder, lb. per sq. in.	8·4	7·3	13·0	12·0	11·7	11·3	14·1	15·5	14·3	13·6	13·4	17·0	19·0	19·6	19·2	18·7	21·7	25·0
25	,, ,, reduced to L.P. cylinder, lb. per sq. in.	24·7	23·6	28·3	29·7	30·1	30·5	32·0	34·6	35·8	35·4	35·4	37·9	39·2	45·3	44·6	43·9	45·8	47·8
26	Indicated horse-power	81·0	78·0	92·0	97·0	99·0	99·0	107·0	108·0	120	118	120	123	128	151	148	143	151	150
27	Steam per I.H.P. per hour, lb.	19·75	20·1	18·35	18·1	18·14	17·78	16·93	17·27	18·2	17·9	17·3	17·2	17·4	18·25	18·4	18·5	18·35	17·9
28	H.P. cylinder feed per revolution, lb.	0·453	0·421	0·415	0·499	0·489	0·468	0·469	0·469	0·605	0·571	0·541	0·559	0·556	0·769	0·747	0·730	0·726	0·720
29	L.P. cylinder feed per revolution, lb.	0·406	0·385	0·387	0·455	0·448	0·434	0·421	0·431	0·584	0·540	0·516	0·514	0·512	0·732	0·718	0·691	0·685	0·669
30	Clearance surface temperature H.P. cover end, deg. Fah.	324	340	345	328	342	344	336	338	335	342	344	342	342	344	349	344	346	347
31	Clearance surface temperature L.P. cover end	192	187	325	205	205	204	306	318	211	209	211	*308	318	222	223	221	—	—

point of cut-off in the high-pressure cylinder was fixed for each trial, any change of pressure or vacuum tended to alter the speed of the engine. An observer was therefore placed at the brake, whose duty it was to watch a tachometer and keep the speed of the engine as constant as possible by varying the brake load. The clearance volumes and surfaces of the cylinders are given in Table I.

TABLE I.—*Particulars of Clearance Volumes.*

	H.P. cylinder.		L.P. cylinder.	
	Cover end.	Crank end.	Cover end.	Crank end.
Clearance volume, cubic feet	0·203	0·180	0·488	0·406
Percentage of piston displacement	9·38	9·05	7·46	6·54

Particulars of Clearance Surfaces.

	Cover end.			Crank end.		
	Jacketed.	Unjacketed.	Total.	Jacketed.	Unjacketed.	Total.
H.P. cylinder—						
Clearance surface, square feet (Crank on dead centre)	0·88	4·05	4·93	1·13	3·80	4·93
Percentage of whole	18	82	—	23	77	—
L.P. cylinder—						
Clearance surface, square feet (Crank on dead centre)	3·57	8·83	12·4	2·07	8·23	10·3
Percentage of whole	29	71	—	20	80	—

The observations on the various trials were made by the third-year students at the school, under the personal supervision of the author. Before carrying out these trials, they had had considerable practice in engine testing, and all of them took the greatest care to get accurate readings. Observations of pressures, temperatures, and revolutions were taken every 5 minutes, of the air-pump discharge every 2½ minutes, and indicator cards were taken every ten minutes. Two indicators were directly attached to each cylinder, one at each end, to avoid inaccuracies in the diagrams due to long connecting pipes. The observations were taken simultaneously, the signal for making them being given by a whistle blown by one of the students. After the trial was completed, the records were plotted on a time basis. This gives an admirable means of checking the results of the various observers, as it enables any inaccuracies to be easily detected.

If the effect of steam jacketing is to reduce initial cylinder condensation, it would appear that the best results ought to be obtained when the engine is running slowly. It was therefore decided to run the engine at about half its normal speed—a fact which ought to be remembered when comparing the results here given with those from engines of a similar type. Had the engine been working at its maximum speed, the consumption in terms of the indicated horse-power would have been much less.

It was decided to carry out these trials with a boiler pressure of 150 lb. per square inch—gauge—at about 60 revolutions per minute, and with a back pressure in the condenser equal to 5in. of mercury. The driving gear was disconnected from the governor, and by means of an arrangement which allowed the governor sleeve to be raised or lowered the point of cut-off in the high-pressure cylinder could be fixed at any part of the stroke. Four sets of trials were

it is the value of r R where r is the fraction $\frac{\text{Stroke}}{\text{Piston travel to cut-off}}$ in the high-pressure cylinder and R is the ratio of the volume of the low-pressure to the high-pressure cylinder. No correction has been made for clearances, as it was felt that the results would be more useful to engine builders if the terms used were those generally employed in every-day commercial work.

The line marked air-pump discharge in the illustrations gives the quantity of steam in pounds per hour that passes through the high-pressure cylinder. As the low-pressure steam chest was drained, the whole of the air-pump discharge did not enter the low-pressure cylinder. The steam condensed in this chest passed through a measuring vessel and thence to the condenser. The amount of this condensed steam for the different trials is given in Table II., line 14. The total steam per hour line shows the air-pump discharge, together with the steam used in the jackets. This latter does not, of course, appear in Fig. 2 (*post*). From the curves of total steam per hour and of indicated horse-power the curve of steam per indicated horse-power per hour has been constructed. This enables one to find the number of expansions at which the engine will work most economically and the best results in terms of the indicated horse-power under the various conditions.

(*To be continued.*)

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(*From our own Correspondent.*)

THE engineering trades keep busy in some branches, with a fair number of good orders on the books for railway and hydraulic work. Electrical requirements are affording steady employment in some cases, though in others short time is in force, and by no means the normal number of hands are employed. The experience of firms is very irregular, some being moderately occupied and others quite quiet, so that it is really difficult to gauge the general state of trade. If all were levelled up, however, the average of employment and work in hand would be found to be only moderate.

Great things are expected from Japan within the next few years, particularly by Midland bridge builders and crane constructors. The Argentine Republic is proving an increasingly valuable market alike for agricultural machinery and for mining machinery.

The gold deposits in the river beds of Bolivia are also reported to be good, and the speculative movement which is going on in that direction will, it is expected, lead to a strengthening of the Bolivian demand for various classes of mining machinery.

Agricultural machinery is in large demand just now for the home districts, especially for hay harvesting purposes, the leading Midland agricultural engineers and implement dealers being very busy. The opinion is being freely expressed in this part of the kingdom that implement and machinery manufacturers ought to have a much better share in the management of the affairs of the Royal Agricultural Society than they have had hitherto, their entrance fees coming to almost twice as much as those of the live stock exhibitors; yet the amount offered for prizes in their classes is ridiculously small, and their general influence in the Society's affairs has not hitherto been reasonably strong. There is a large number of members in Warwickshire, Worcestershire, Shropshire, and Staffordshire, among whom it is felt that at the ensuing first election of the Council under the new supplementary charter an effort should be made by agricultural engineers to secure a better status. Portable steam engine builders are busy, and some of the traction engine builders have fairly good orders in hand, and oil-engine builders are busy both on stationary and portable types.

The iron and steel trades continue fairly cheerful. The demand for iron and steel has been upon a modest scale during the week—scarcely sufficient, in fact, to test prices. There are, however, no signs of serious shrinkage, and on the whole the trade may be reported as healthy. Makers of best finished iron are steadily employed, but common iron is not going off so satisfactorily, and makers complain that prices are unremunerative. The reduction of 2s. 6d. per ton in gas strip has not added greatly to the orders on hand. Hoop iron is selling slowly. Galvanisers are well engaged, whilst quotations in that branch continue firm. No alteration, however, has been made in the price recently declared by the new combination, the leading firms still quoting £10 12s. 6d. for 24 gauge, delivered Liverpool. There is an improved demand for black sheets, and the higher rates recently secured are maintained at £6 10s. to £6 15s. for singles, £6 12s. 6d. to £6 17s. 6d. for doubles, and £7 5s. to £7 10s. for trebles.

The pig iron trade is rather quiet, with values unchanged on the week. Steel makers are steadily occupied. The coal trade is very quiet.

NOTES FROM LANCASHIRE.

(*From our own Correspondents.*)

Manchester.—General resumption of business after the Whitsuntide holidays has been slow in this part of Lancashire. Although the attendance on the Iron 'Change on both Friday and Tuesday was well up to the average, many prominent buyers were absent, and those who were present operated for immediate requirements only. Indeed, there was a marked absence of the speculative element, and orders were placed only on the lowest possible basis. Warrants do not seem to have changed much in the meantime. All classes of pig iron are dull, although we are free to admit there is a better feeling forward. No doubt the yearly stocktakings, which are now in full swing, interfere with buying. Scotch pig seems to have touched "bottom," and there have been some attempts to run up the figure a little, but apparently without success. Of Lancashire foundry No. 3 there is no great quantity in stock, and attention is being paid to the completion of contracts on hand. Other English makes are very quiet.

Quotations:—Lancashire No. 3 foundry, 52s. to 53s.; Lincolnshire, 50s. 6d.; Derbyshire, 52s. to 52s 6d.; Staffordshire, 52s. 6d.; Middlesbrough, open brands, 54s. 10d. to 54s. Scotch: Gartsherrie, 55s. 6d.; Glengarnock, 53s. 6d.; Eglinton, 53s.; Dalmellington 52s. 6d., delivered Manchester. For delivery Heysham: Gartsherrie, 53s. 3d.; Glengarnock, 51s. 9d.; Eglinton, 51s.; Dalmellington, 50s. 6d.; West Coast hematite, 56s.; East, 54s.; No. 3 G.M.B., 45s. 6d., f.o.t.

Forge iron is in little request, although one or two makers report that they are fully sold. Still, orders can be put through at low rates. Lincolnshire, 46s. 8d., equal to delivery Warrington; Derbyshire, 46s. 4d. to 47s., same delivery.

Finished iron is steady, and prices are unchanged. Crown bars, £6 5s.; hoops, £7 to £7 5s.; sheets, £7 5s. to £7 10s. In steel products there is a strong inquiry for plates and angle iron, but the prices offered by buyers are not sufficiently tempting to induce business, as a rule. Billets are quiet. English, £4 2s. 6d. to £4 7s. 6d.; hoops, £7 2s. 6d. to £7 5s.; boiler plates, £6 to £6 2s. 6d., delivered Manchester. In machine tools there appears to be a run on those for turbine work, and some fine specimens are being turned out in various shops in the district. Textile machinery makers also continue well employed.

Copper, tin, spelter, &c., maintain, and, if anything, improve, on recent rates. There is, however, no change to report in manufactured copper, sheets being quoted £79 to £81 per ton; seamless tubes, 10½d.; brazed, 10d.; brass tubes, 8d.; condenser, 9d.; brazed brass, 8½d.; rolled brass, 6⅞d. to 7¼d.; brass sheets, 7⅜d. to 8d. per lb.

The quarterly meeting of the Manchester Association of Engineers was held on Saturday evening at the Grand Hotel, Mr. R. Matthews, President, occupying the chair. Eight new members were elected. The business was purely formal. At the close the President alluded to the forthcoming excursion to Portsmouth, including a stay in the Isle of Wight, and mentioned that the London and North-Western Railway Company had given facilities whereby some hours could be spent in London on the Monday on the return journey. He invited any suggestions, but, as the secretary, Mr. Frank Hazelton, had evidently anticipated anything in the way of novelty, the proceedings terminated.

In the coal trade there are great complaints of want of business, especially in fuel for domestic purposes. Pits are not on full time, and, as a large quantity of slack is being sent into the district from the Derbyshire and Nottingham coalfields, this department is not now so busy as it should be. There appears to be, however, no giving way in prices, although there are odd lots which are obtainable at under list rates. Shipping demand is only normal. Best house coal, 13s. to 14s.; medium, 12s. to 13s.; common, 9s. to 10s.; steam and forge coal, 8s. 3d. to 8s. 9d.; best engine fuel, 7s. 9d. to 8s. 6d.; best slack, 7s. to 7s. 6d.; medium, 6s. to 6s. 9d.; common, 5s. to 5s. 9d. at the pit. Screened coal, 9s. 9d. to 10s.; unscreened, 9s. 3d. to 9s. 6d., delivered Manchester Ship Canal.

Barrow.—The hematite pig iron trade remains quiet, and buyers have shown some disposition during the week to reduce prices, although officially the quotation for mixed Bessemer numbers remains steady at 57s. 6d. net f.o.b. Warrant iron is at 55s. 6d. net cash sellers, buyers 6d. less. Orders are not coming to hand for heavy parcels, nor is there much business doing in forward deliveries. Makers are not well off for orders, with the exception of those who produce iron for conversion into steel. There are 33 furnaces in blast on hematite. It was expected that some of these would ere this have been blown out or damped down, but makers still keep their output steady in the belief that the depression at present in the market is only of a temporary character and will give place soon to a stronger market. The belief, however, is generally held that no real improvement will take place until the

* "Proceedings," North-East Coast Institution of Engineers, Vol. 16.

war in the Far East is over, and that then there will be a boom, providing current continental complications are also settled. Warrant iron stocks are 140 tons down this week, and now stand at 21,155 tons. Makers' stocks show a small increase.

Iron ore is quiet in tone, and the output of the mines is restricted. Prices show no variation, good average sorts being at 8s. 6d. to 9s. 6d. net at mines. Spanish ores are at 14s. 3d. net at West Coast ports.

Steel makers are not well employed in many of the departments, but heavy rail orders still keep the mills at work, although new business is scarce. Prices are at about 105s. per ton. It is believed, if lower prices prevailed, fuller business could be done. A few new orders have been placed for steel shipbuilding material, and others of some importance are expected to follow at an early date; but in merchant steel business remains quiet, and these departments are not more than half employed.

Next Tuesday Princess Arisugawa will launch the Japanese battleship Katori from Vickers' yard at Barrow. This firm has booked the order for the turbine machinery for the new British battleship Dreadnought. The energy to be developed is from 22,000 to 23,000 indicated horse-power, and the speed of the vessel is to be about 21 knots.

Shipping remains quiet at West Coast ports. Last week the exports were 6190 tons of pig iron and 8284 tons of steel, making a total of 14,474 tons, in contrast with 14,241 tons in the corresponding week of last year—an increase of 233 tons. The aggregate shipments this year have reached 406,829 tons, in contrast with 364,562 tons in the corresponding period of last year, showing an increase of 42,267 tons.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

THE collieries throughout the South Yorkshire district are now working quite up to the average at this season of the year, and a heavy weight of coal is being raised. The demand is chiefly for steam fuel, in which, with the exception of the Baltic ports, a good business is being done. In house coal, the output is in excess of market requirements, but this condition of affairs is certain to be altered during the next couple of months, owing to the large number of local "feasts," which are fully observed by the mining population. The stoppage on account of these feasts will cause the accumulations to diminish, and tend to steady prices, which, at the time of writing, are somewhat feeble and fluctuating. For London and the South, house coal is being taken in rather diminished quantities, and the trade done with the Eastern Counties markets is also reported to be light. Current quotations are as follows:—Good Silkstone, 11s. to 11s. 6d. per ton; secondary qualities, 9s. to 9s. 3d. per ton; Barnsley, first quality "softs," 9s. to 9s. 6d.; other qualities, about 8s. per ton; Barnsley thin seam coal is quoted from 7s. to 7s. 6d. per ton at the pits in owners' wagons.

In steam coal trade is active, and, in view of the abnormally large quantity brought to bank, business is good. Coalowners, however, complain that prices are difficult to maintain, even at their present low rates. For locomotive purposes, 8s. to 8s. 3d. per ton are the contract rates, but these are not quite reached for shipping purposes. Steam coal is being consigned in considerable tonnages to both Hull and Grimsby, a large portion of the coal taken to both ports being to meet the requirements of the steam trawlers. Shipments to foreign ports are considerably less than they were at the corresponding period of last year. In the open market there is not much demand for steam coal, which is easily obtainable at 8s. to 8s. 3d. per ton at the pits.

For gas coal the request at present, as is usual at this season of the year, is exceedingly moderate. After considerable negotiation, contracts for the next six months have been placed by gas companies and Corporation gas departments at the old rates. In several instances it is said that slight reductions in prices have been obtained, but these concessions have certainly not been made in the standard qualities usually contracted for by the large undertakings.

For slack and smudge there is still a brisk demand in the Manchester cotton districts, but for the woollen trade localities there is less doing. Engine fuel of all descriptions sells readily, and values have been rather harder of late to the extent of 3d. and 6d. per ton. Slack and smudge are in good request, and prices are well maintained. The coke trade itself is somewhat affected by the increased output from the by-product plants. Prices are not quite so easily maintained owing to the heavy tonnage which is being thrown on the market. Both Lincolnshire and Derbyshire are still taking a fair weight, which will be largely increased when the iron trade is in a more animated state.

No change is reported in the quotations of hematites, which have been stationary now for a considerable time. In Lincolnshire irons, however, a decrease of 1s. per ton has to be noted, Lincolnshire forge No. 4 being now at 44s., and Lincolnshire foundry No. 3 at 48s. 6d. Derbyshire prices remain as before—forge at 43s. 6d. to 44s.; foundry, 48s. 6d. There is rather more doing in the Bessemer and Siemens furnaces. In the crucible steel department the principal brands are being more freely ordered on account of the home market, which is waking up in several localities. The demand for foreign markets is well maintained, and has, indeed, considerably increased of late.

The condition of affairs in the heavy material trades remains unaltered, but the general impression is that the second quarter now closing has steadily improved during the last few weeks. The prospects for the second half of the year are regarded as more encouraging. The new armour plate orders cannot now be much longer delayed, and though they are not likely to be large, they will be very welcome in the departments they concern. Heavy forgings and castings are being inquired after for the shipbuilding yards, but work comes very slowly to hand, and it is much needed. Railway material, on the other hand, is being more freely called for, both on home and foreign account. The Japanese are in the market for rolling stock, of which rapid delivery is required.

The lighter trades of the city, more especially in cutlery and silver, have rarely been in a less satisfactory condition owing to the stagnation in the home market, while the colonial and foreign business is, at the same time, somewhat disappointing. Many of our cutlery artisans are out of employment, with no prospect of any immediate change for the better. There is a little more inquiry for silver, the cheapness of which induces buyers to take wares in the sterling metal in preference to electro-plate. Silver is just about half the price it was some years ago, and then there was a duty of 1s. 6d. per ounce. Now there is no duty.

The directors of Messrs. John Brown and Co., Limited, in their annual report issued on the 28th inst., states that for some time they have had under consideration the desirability of entering on the manufacture of ordnance, and that with this object negotiations are in progress for the acquisition of a half share in the Coventry Ordnance Works of Messrs. Cammell, Laird and Co., Limited. They add that no further capital will be required at the present time, as the existing resources of the company are sufficient for the purpose.

In the course of their provincial tour the members of the Canadian Manufacturers' Association visited Sheffield on the 28th inst. They were the guests of the Sheffield Chamber of Commerce, who entertained them to luncheon at the Cutlers' Hall. Several works representative of the heavy and light industries of the city were visited, the Canadians being divided into parties for the purpose. At the East End, where the heavy trades are carried on, the works visited were Vickers, Sons and Maxim, Hadfield's Steel Foundry, Cammell, Laird and Co., Thomas Firth and Sons, William Jessop and Sons, and William Cooke and Co.; in cutlery, silver, and plating the Canadians saw the works of Joseph Rodgers and Sons, James Dixon and Sons, Walker and Hall, Mappin and Webb, William Hutton and Sons, and Thomas Turner and Co.; and the list also included the Spring Grove Paper Mills of Messrs. Peter Dixon and Sons, Oughtibridge. In the evening the Canadians attended a reception by the Lord Mayor and Lady Mayoress of Sheffield at the Town Hall. The next morning they left for Leeds.

NORTH OF ENGLAND.

(From our own Correspondent.)

NOT for many years have prices of pig iron in this district moved so little as has been reported in June; practically they have been stationary, the buyers' price of Cleveland warrants and No. 3 having stood at 45s. 6d. per ton. This is in great contrast to the condition of things in May, when prices were very unsettled, and went up to higher figures than have been known for several years and dropped heavily in the latter part. Nevertheless, the stiffness of prices does not lead to briskness in buying, it rather tends the other way, and consumers keep to their policy of buying from hand to mouth—they do not believe that prices will move upwards, and the probability is that they will be lower. At any rate, it is thought that the waiting policy is the best at present, for the summer season is generally a quiet time, with stationary, if not falling, prices, so far as regards pig iron.

The sales of Cleveland pig iron are now made by the producers themselves, no one apparently caring to purchase warrants, as there is no advantage in getting them. Producers are not going to let the syndicate of speculators undersell them, and if the latter reduce their prices the makers will do so likewise. The syndicate cannot well afford to take less than 45s. 6d. per ton for Cleveland warrants, and thus they are holding to them. It is now believed that they will continue to hold their warrants until the autumn, when, if precedent is followed, there will be some improvement in prices. At 45s. 6d. per ton makers are getting back some of their old custom, and they would secure more if further reductions were made, 45s. 6d. being too much for most of the Continental consumers. No. 1 is at 47s., No. 4 foundry at 43s. 3d., No. 4 forge at 42s., mottled at 41s. 6d., and white at 41s. per ton. With No. 4 foundry at a price 2s. 3d. per ton lower than No. 3, instead of 6d. only, it is inferred that No. 3 is still at a figure which may be looked upon as artificial. The actual trade does not warrant its being kept so high, and doubtless it is maintained at that because warrant holders are unprepared to lower their rates.

The prices of East Coast hematite pig iron are rather weak, notwithstanding that the supply is not large and that the steel manufacturers are doing fairly well. The influences are in favour of better prices, but that does not strengthen sellers, partly because the competition of West Coast producers is keen. Mixed numbers of East Coast hematite pig iron are at 54s.; No. 1, at 54s. 6d.; and No. 4, at 51s. 6d., but some mixed numbers have been sold at 53s. 9d. Rubio ore is firm at 15s. 9d. per ton c.i.f. Tees, but it cannot be said that merchants have yet realised that figure.

Connals have still to report increasing stocks of Cleveland pig iron, and now they hold over half a million tons—it was 500,605 tons on 28th, the increase for June being 13,155 tons, which is too much. It is evident that the production is still in excess of the requirements, but there are no indications that any firms are likely to blow out any of their furnaces.

It is satisfactory to note for June a substantial improvement in the exports of pig iron from Cleveland; they have been poor for months, owing to the disorganisation brought about by the gamble in warrants, but now they are brisker than they have been since last August, and producers are making up for the short deliveries of last month, when some of them sent the iron into the public stores, letting the consumers wait for some of their iron. The prices having declined Cleveland makers are regaining the custom of former regular consumers, who were driven elsewhere in the spring, when speculation greatly interfered with trade. For Scotland, Cleveland iron is again cheaper than Lincolnshire, and shipments have therefore increased very considerably. Trade with Germany, however, still leaves a good deal to be desired, for Cleveland iron is not low enough by 2s. 6d. per ton to compete in that country with native iron. The shipments of pig iron this month have been 85,095 tons, as compared with 68,681 tons in May, 68,160 tons in June, 1904, and 104,240 tons in June, 1903, all to 28th.

The manufactured iron and steel industries show improvement in several branches, and prospects are generally good, a fact which is taken note of by the investing public, for the market values of the shares of some of the leading concerns in the North of England are increasing. A more sanguine view of the business of the second half of the year must be reported. But as yet no alterations in the quotations have been made, the present figures having ruled for several months. Any changes are expected to be in an upward direction. The busiest works at present are those producing railway and shipbuilding materials, though this week at most of the large establishments on Tyneside—shipbuilding, engineering, and iron and steel works operations are suspended for the whole week on account of Newcastle Races, which period is looked upon as the Tyneside "Pitmen's Carnival."

SIR David Dale, Bart., who is connected with so many industrial concerns in the North of England, prominent among which is the Consett Iron Company, of which he is chairman, is now paying a visit to the Dunderland iron ore mines in Norway. Of the company operating these, Sir David is chairman. The development of these mines is so far advanced that the first shipment of ore briquettes is expected to be made in the autumn.

Work at the shipyards continues steady, but there are not many new orders to be secured. However, there are contracts booked which will afford employment during most of the second half of the year.

The coal trade is showing a little improvement, and on account of the holidays on Tyneside it has been impossible to get full supplies for export. A brisker demand has been induced by the rise in Mediterranean freights, which, as it was rather unexpected, will bring about a loss for c.i.f. shippers. The demand for prompt coal has been keen, but some difficulty has been experienced in securing steamers to carry it. The Northumberland colliers have rescinded their decision to ballot the county as to whether the men are prepared to strike to enforce an advance of wages for the boys and free coal and rent allowance for single householders. The owners are inclined to compromise the matter, and a deputation of the men will wait upon them shortly. The coke trade is steady, and is likely to continue so as long as the output of pig iron is kept up. Not less than 15s. 6d. per ton delivered at the Middlesbrough furnaces will be taken. Messrs. Cochrane and Co., Middlesbrough, are about to erect at their new Brancepeth Colliery, near Durham, a large number of by-product coke ovens of the Otto-Hilgenstock type, capable of producing 90,000 tons of coke per annum. Other leading coke manufacturers are likely to follow in adopting the retort oven with by-product recovery plant.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

THE Scotch iron trade has been quiet since last report in all its departments. No doubt there are in some branches considerable orders on hand, but the amount of fresh business coming forward is limited, and at this particular season it is not likely that there will be any substantial improvement. The state of trade generally is backward, and a good deal of harm has been done in several important industries by strikes of workmen. Advices from abroad generally indicate that trade continues quiet.

The Glasgow pig iron market has, during the week, been inactive. Almost every day a quantity of warrants has been changing hands, but prices show little variation, and the business is mainly of a formal description.

Cleveland warrants have sold at 45s. 6d. cash, and 45s. 8½d. one month, while Scotch warrants are quoted 49s. 4½d., and Cumberland hematite 55s. 10½d. per ton. Standard foundry pig iron is at 44s. 3d. per ton.

There has been the small decrease of 140 tons in the stock of Scotch ordinary warrants in the Glasgow stores, which now contain 17,748 tons Scotch, and 7441 standard foundry pig iron.

The demand for pig iron on the part of home consumers and shippers is quiet, but the output is maintained. There are 41 furnaces making hematite, 38 ordinary, and 6 basic pig iron, the total of 85 furnaces thus blowing in Scotland comparing with 86 at this time last year.

The prices of Scotch makers' iron are in a number of cases 6d. per ton lower. G.M.B., No. 1, is quoted at Glasgow, 53s.; No. 3, 50s.; Carnbroe, No. 1, 54s. 6d.; No. 3, 51s.; Clyde, No. 1, 56s. 6d; No 3, 51s. 6d.; Gartsherrie, Summerlee, and Calder, Nos. 1, 57s.; Nos. 3, 52s.; Langloan, No. 1, 60s; No. 3, 53s.; Coltness, No. 1, 63s. 6d.; No. 3, 53s. 6d.; Glengarnock at Ardrossan, No. 1, 58s.; No. 3, 52s.; Dalmellington at Ayr, No. 1, 54s.; No. 3, 49s.; Eglinton at Ardrossan or Troon, No. 1, 52s. 6d.; No. 3, 50s.; Shotts at Leith, No. 1, 59s.; No. 3, 54s.; Carron at Grangemouth, No. 1, 57s. 6d.; No. 3, 52s. 6d. per ton.

Scotch hematite pig iron meets with a fairly steady demand, large quantities being required for the manufacture of steel. Merchants quote for this class of iron 58s. 6d. per ton for delivery at the West of Scotland steelworks.

The shipments of pig iron from Scottish ports in the past week amounted to 5068 tons, compared with 2878 in the same week of 1904. There was despatched to the United States 900 tons, Canada 291, South America 15, India 125, Australia 258, France 20, Italy 10, Germany 225, Holland 150, China and Japan 300, other countries 250, the coastwise shipments being 2524 tons, compared with 1629 in the corresponding week of last year.

The arrivals of Middlesbrough pigs at Grangemouth were larger than for some time, amounting to 14,707 tons, against 9497 tons in the corresponding week, showing an increase of 5210 tons.

The finished iron and steel trades exhibit at the moment scarcely any feature of fresh interest. Work is proceeding steadily on existing contracts, but complaints are heard that new business is scarce and very keenly competed for. Some of the ironfounders are in good employment, while others are quiet, and this is also the case with the boilermakers and the general engineers. Comparatively little fresh business is coming to hand in the shipbuilding trade. The Clyde Shipbuilding and Engineering Company, Port Glasgow, has received an order to engine a steamer of 3000 tons deadweight, and this is the only order of any consequence that has been reported for several days.

The volume of business in the coal trade is good for the season. The total shipments from Scottish ports in the past week amounted to 263,810 tons, compared with 255,382 in the preceding week, and 271,823 in the corresponding week of last year. The shipments to continental ports are well maintained, and there is also a fair coastwise business doing, long distance cargoes being less numerous at the moment. The prices of coal are nominally unaltered. There is a good demand for manufacturing sorts, but the household qualities have been in poor demand for home use, owing to excessively hot weather.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

THE demonstration at Cardiff this week, on the occasion of the visit of the Prince of Wales to place the foundation stone of the new college building, has affected, in a degree, collieries, works, and dock business. I was reminded this week in the streets of the Welsh capital, of past events in connection with the late Lord Bute, to whom so much is dne for the industrial enterprise which has been in harmony with mining developments, and very shortly, I am told, the present Marquis will enter upon similar labours.

The steam coal trade has not been marked with any briskness, nor has there, fortunately, been any sign of bad augury for the future. In a visit around the great collieries and railways there was not any increased dejection apparent. Ample supplies of coal were to be seen, but I was informed that a fair amount of trade is being carried on with prices at the old level, and that some owners are well sold for months ahead. In small steam there is less animation, the demand being fairly sustained, and prices still above the old rates. One does not hear of 9s., but 8s. 3d., and even 8s. 6d., are ordinary quotations. Monmouthshire coals are slightly weaker, and flatness is a characteristic of all house coals. The "shifting" of house coals on some of the lines has been of late a very slow movement.

Latest quotations for all classes of coal this week at Cardiff were as follows:—

Best steam coal, 12s. 6d. to 13s.; best seconds, 12s. to 12s. 3d.; seconds, 11s. 6d. to 11s. 9d.; drys, 11s. 6d.; best small steam, 8s. 3d. to 8s. 6d.; best ordinaries, 7s. 9d. to 8s.; seconds, 7s. 3d. to 7s. 6d.; inferior from 7s. Monmouthshire coal: Best large, 11s. 3d. to 11s. 6d.; best ordinaries, 11s. to 11s. 3d.; seconds, 10s. 3d. to 10s. 9d. House coal: Best, 14s. 9d. to 15s. 3d.; best ordinaries, 12s. 6d. to 13s. 6d.; seconds and other kinds, 10s. 6d. to 11s. No. 3 Rhondda, 13s. 9d.; brush, 11s. 9d.; small, 9s. 9d. to 10s. No. 2 Rhondda, 9s. 6d. to 9s. 9d.; through, 8s. 3d. to 8s. 6d.; small, 7s. to 7s. 3d. Patent fuel, 13s. to 14s. Coke, 16s. to 16s. 3d. for furnace; 17s. 6d. to 21s. 6d. for foundry, according to quality. Pitwood is easier—18s. 6d. to 18s. 9d.

At Swansea this week the Exchange report was to the effect that a quieter tone prevailed than last week. During last week only 45,000 tons coal were shipped, but over 15,000 tons patent fuel. France continues a fair demand for both. Steam coal quotations, 12s. to 12s. 6d.; No. 3 Rhondda, 13s. 6d. to 14s.; patent fuel, 11s. 6d. to 11s. 9d. Anthracite coals as follows:—Best malting, 19s.; second, 16s.; big vein, 11s. to 11s. 3d.; red vein, 9s. 6d. to 9s. 9d.; cobbles, 15s.; nuts, 16s. to 17s.; peas, 11s.; rubbly culm, 6s.; duff, 3s. 6d.; patent fuel, 11s. 6d. to 11s. 9d. Little chartering has been done. Some cargoes of fuel to France went mid-week, one an export of 1300 tons. Cardiff continues its fuel shipments to the West Indies, one cargo of nearly 2000 tons going mid-week.

It is reported that Livingstone and Co., as agents for the Atlantic Fuel Company, Limited, have just contracted with the French State Railways for the supply of 40,000 tons fuel for French railways in North Africa.

The weather told last week upon work at mills and furnaces; still, an average make was the result. Cardiff despatched one large cargo of rails foreign. Bars and billets, both from America and Germany, have been again in evidence at Welsh ports, and steel ingots from Queensferry have been received at the Mannesman Works, Swansea, where employment continues very satisfactory. In the Swansea Valley there have been a few interruptions to the usual vigorous conduct of work; the Midlands have been affected, and at the Worcester Works four mills were interfered with, and the Duffryn—some idleness caused by the bursting of pipes. Most of the stoppages were of a temporary character, and the lessened make of tin-plate only transitory.

That the trade is promising was indicated by the shipment of 100,812 boxes last week, and by the receipt from works of 86,607 boxes. Present stocks are 226,149 boxes.

At the Bessemer works the bookings for rails and sleepers are quite up to expectation, and there has been no falling off in receipt of Spanish ore for the leading works. This week I saw, in transit on the Rhymney line, a large consignment of fine character, and had occasion then, as on other visits, of noting the

ability with which the varied and considerable quantities of make and produce are handled in alternation with the increasing passenger traffic. Constant trains of coal from collieries to port, rails, bars, fish-plates, &c., from works, and ore and merchandise from dock to chief towns, giving little, if any, cessation to traffic, either night or day.

Iron and steel prospects are regarded as satisfactory, and shipbuilding this year is expected to give an impetus to steel make. Guest, Keen and Co. have started a washery and coke oven at their Nettlefolds Works, Cwmaman, which will lead to the employment of 200 additional hands.

In connection with the sheet mill wages movement at Swansea, the result of a conference has been to carry out certain scale alterations.

On 'Change, Swansea, mid-week it was intimated that foreign dumping was certain; pig iron, Scotch and Middlesbrough, unaltered; hematite advanced 6d. per ton. In tin-plate, considering the large production going on, some makers, it was said, viewed the rumoured difference in the labour market with tranquility, as a "little stoppage would strengthen prices, and enable makers to resist bearing tactics."

Latest quotations are:—Glasgow pig, 49s. 6d.; Middlesbrough No. 3, 45s. 6d.; hematite warrants, 56s.; Welsh bars, £5 17s. 6d. to £6; sheet iron, £7 10s. to £7 15s.; steel sheet, £7 10s. to £7 12s. 6d.; steel rails, heavy, £5 5s. to £5 10s.; light, £6 5s. to £6 10s.; Bessemer bars, £4 5s.; Siemens, £4 6s. 6d. Tin-plates: Bessemer, 11s. 6d. to 11s. 7½d.; Siemens, 11s. 7½d. to 11s. 9d.; ternes, 21s. to 21s. 6d.; best charcoal, 13s. to 13s. 3d.; big sheets, £8 5s. to £8 7s. 6d.; finished black plate, £8 2s. 6d. to £8 10s. per ton. Copper, £66 13s.; block tin, £139 12s. 6d.; spelter, £24; lead, £13 8s. 9d.; iron ore, 14s.

The article in THE ENGINEER of last week upon the "Iron Ore Deposits in Foreign Countries," with special reference to those available to this country, has been favourably commented on in this district, as yielding information of the very kind needed. For a long time rumours have been floating with regard to Bilbao, and though present needs are estimated as being secure for twenty years, opinions prevail that requirements may be largely in excess of the present, and a falling supply is certain to be accompanied with increased cost. Upon one statement in the article in question that concerns Swedish ore, local interest in centred, and the enterprise of Baldwin and Wright at Cwmavon is being carefully followed. This is the process in which Swedish ore is compressed into briquettes before smelting. A range of small furnaces, I hear, is projected similarly to that in use on the Continent.

The contractors for the extension of the Alexandra Dock, Newport—Messrs. Easton, Gibb and Son, Westminster—will now begin the important work, the plant arriving this week on board the steamer Arrival. It is estimated that about three million cubic yards of earth will have to be removed. The work is expected to take eighteen months, and occupy a thousand men. Contract price was near £250,000, and this carried out will put Newport on a footing with the best of the Channel ports. This week the Prince of Wales was taken around the great undertaking of the new dock at Cardiff. There, as at Swansea and Bristol, progress is prominent, though, as in all these immense labours, it is not very marked to the ordinary looker on.

I have previously referred to the constant developments taking place on the Cambrian to meet the summer season traffic, now, it is stated, that the Great Western Railway will work the Manchester and Milford. This will give Aberystwith increased facilities. A large addition to passenger traffic is expected on all lines from the 1st July.

NOTES FROM GERMANY.

(From our own Correspondent.)

PIG iron is in active request on the Silesian market, and stocks are very low. All articles of manufactured iron remain in lively demand, and prices are satisfactory.

From the Rhenish-Westphalian iron industry good reports are coming in, an active trade being done in nearly all departments. The mills and forges are well supplied with work for several weeks, so a slight falling off in demand that is being felt in some branches does not affect the tone of the market, which is steady and brisk. In pig iron a healthy business continues to be done, home demand being pretty extensive, especially for foundry pig and iron for steel making.

The monthly accounts of the Pig Iron Syndicate in Düsseldorf show the number of orders booked, as well as deliveries, during May and in the present month to have been exceptionally high. From Siegerland less favourable accounts are given, at least with regard to the pig iron trade, the blast furnace works in that district producing less by some 15 to 20 per cent., and exports have been of comparatively little weight. On the whole, however, the Siegerland iron trade shows increasing liveliness in many departments. Iron ore sells freely, but quotations are still rather low, and are not likely to meet with any improvement until the general position of the market has increased in firmness. Semi-finished steel is likewise in good demand, both on home and on foreign account.

The bar trade in the Siegerland, as well as the boiler-making establishments, are in better occupation than some months ago, whereas the sheet mills are doing a hand-to-mouth sort of business. The semi-finished steel trade in Rheinland-Westphalia is active, and, on the whole, improving, makers asking long terms of delivery. Prices have not changed, and, being satisfactory, will be maintained through the third quarter. The office of sale for export in Düsseldorf states that the Rhenish-Westphalian Coal Syndicate, in Essen, the Pig Iron Convention, in Düsseldorf, the Siegerland Pig Iron Convention, and the German Steel Convention have given permission to grant export bounties, in the third quarter of the present year, up to M. 1·50 p.t. for coal, M. 4·86 p.t. for pig iron, M. 15 p.t. for semi-finished steel, including the bounty for coal and pig iron, and M. 20 p.t. for manufactured iron. The Coal Syndicate and the Steel Convention have already granted the same bounties as hitherto paid for the last quarter of the present year. These bounties are to be paid only to the works belonging to syndicates. Iron bars are in strong request, also bars in basic, and if M. 112 to M. 115 p.t. is still the price generally quoted, it is because dealers come to the market with cheap offers. In drawn wire and in wire nails a steady, in some instances brisk, trade is done, and the mills have secured orders for months ahead.

The locomotive and wagon shops report themselves in active occupation, having contracts on their books that will keep them well engaged till far into autumn, when further Government orders are expected to be given out. Quite recently the locomotive shops Hendschel-Kassel, Egestorf-Hanover, Borsig, and Schwarzkopf-Berlin, have received orders of considerable weight from South America and Asia. The contracts, which are worth 12 million marks, will have to be completed before the end of the present year.

Latest list quotations for raw and finished iron are as under:—Forge pig, M. 56; iron for steel making, M. 58; spiegeleisen, M. 57·50 p.t., free Siegen. Basic, M. 57·50; foundry pig, No. 1, and hematite, M. 66 to M. 67; foundry pig, No. 3, M. 63 to M. 64 p.t.; free at works. Raw bars, M. 77·50; billets, M. 90 p.t.; plates in basic, M. 92·50 p.t.; for Siemens-Martin quality, M. 5 p.t. more is paid. Scrap iron, M. 48 to M. 56 p.t., according to quality. Iron rails, M. 73 to M. 74 p.t. Malleable iron bars, M. 112 to M. 115 p.t. Good merchant bars and nail rods, M. 128 to M. 132 p.t. Hoops, M. 123 to M. 124 p.t. Girders, M. 112 to M. 115 p.t. Heavy plates, M. 118 to M. 120; boiler plates, M. 130 to M. 135; and thin sheets, M. 120 to M. 122 p.t. at works.

The position of the Austro-Hungarian iron market does not show any change as compared with the previous week, business in the principal articles of iron and steel remaining fairly brisk. In pig iron especially a steady and satisfactory demand was noticeable during the week; several Bohemian and Moravian iron foundries have received orders for immediate delivery from the machine factories in Budapest, which had been put to inconvenience by the iron and metal workers' strike in that town. In girders a pretty active business is still being done, though in a number of cases a falling off in demand could be noticed as against previous weeks. The condition of the plate market is unchanged. In July or August rail orders of about 40,000 q. for the Alpine Railways will be placed.

The number of orders coming in on the Austro-Hungarian coal market has been comparatively large, the Ostrau coal trade being quite brisk, on account of the orders received, and so the physiognomy of the coal industry is brighter than before. At the cokeries orders abound; the present favourable state of the coke trade is therefore not likely to alter for the present.

The conflict between coal exporters and private shipping companies, concerning a 10 per cent. rise in the Elbe freights, which would have been of considerable importance to the position of the Bohemian coal market, has been satisfactorily arranged, by an agreement to pay 5 per cent. more, and extra freights when the Elbe is 65 cm. above the average height.

The slow rise in the prices for finished iron in Belgium, which is in no proportion to the advance in raw material, acts somewhat depressingly on the condition of the market, though the number of orders booked during the week is satisfactory.

All sorts of coal in Belgium are stiff in price, and in good call.

In the iron and steel trades of France satisfactory conditions prevail, employment remaining lively in nearly all districts.

On the coal market, likewise, a steady business is transacted, and much firmness has been shown with regard to prices.

THE NEWPORT HARBOUR COMMISSIONERS' WEEKLY TRADE REPORT.

STEAM coal market quiet, tonnage being still rather scarce. House coal, owing to warm weather, is dull. The quantity of coal shipped for the week ending 24th was 58,169 tons—foreign, 45,670 tons; coastwise, 12,499 tons. Imports for the week ending 27th:—Iron ore, 5029 tons; pig iron, 650 tons; steel bars, &c., 4715 tons; cement, 170 tons; slates, 110 tons; deals, &c., 3335 loads; pitwood, 4808 loads.

Coal: Best steam, 11s. to 11s. 3d.; seconds, 10s. to 10s. 3d.; house coal, best, 14s.; dock screenings, 8s. to 8s. 3d.; colliery small, 7s. to 7s. 3d.; smiths' coal, 9s. Pig iron: Middlesbrough, No. 3, 45s. 6d., prompt. Iron ore: Rubio, 14s. 3d. to 14s. 6d.; Tafna, 15s. 3d. to 15s. 6d. Steel: Rails, heavy sections, £5 5s. to £5 10s.; light ditto, £6 5s. to £6 10s. f.o.b.; Bessemer steel tin-plate bars, £4 5s.; Siemens steel tin-plate bars, £4 6s. 6d., all delivered in the district, cash. Tin-plates: Bessemer steel, coke, 11s. 6d. to 11s. 7½d.; Siemens, coke finish, 11s. 7½d. to 11s. 9d.; pitwood, 18s. 6d. to 18s. 9d. ex-ship. London Exchange telegrams: Copper, £66 to £66 2s. 6d.; Straits tin, £139 10s. to £139 15s. Freights steady.

NAVAL ENGINEER APPOINTMENTS.

THE following appointments have been made at the Admiralty:—

Engineer Rear-Admiral: R. J. Tench, to the Victory, for two weeks' course of instruction in oil fuel.

Engineer Commanders: C. McK. Norris, to the Juno; S. Godbeer, to the Argonaut; C. F. H. Tilbrook, to the New Zealand; W. G. Mogg, to the Hood, on commissioning; G. R. Taylor, R. W. Green, S. J. Drake, and C. H. Steward, to the Victory, for two weeks' course of oil fuel; F. T. George, to the Hannibal; B. J. Barnes, to the Arun, for charge of machinery, also for Malta R.N.R., and to assist engineer captain of Malta Reserve; G. W. Murray, to the Aboukir; W. H. Rawlingson, to the Mars.

Engineer Lieutenants: J. H. C. Herne, to the Hermione; E. V. Waud, to the Juno; C. F. B. Pendleton, to the Victory, for the Thorn; F. Ranken, to the Argonaut; T. Garnel, to the New Zealand; S. R. Lewis, to the Hood, on re-commissioning; H. J. Leader (lent) and E. W. Liversidge, to the Victory, for two weeks' course of oil fuel; G. E. Andrew, to the London; H. E. H. Ash, to the Wildfire, for service with engineer rear-admiral; V. E. Snook, to the Sappho; J. J. Screech, to the Illustrious; and C. H. A. Bermingham, to the Sapphire, for the Racehorse; J. B. Barrett, to the Pembroke, supernumerary; J. D. Wilson, to the Sapphire, for the Vixen; W. R. Fendick, to the Aboukir; W. R. Parnall, to the Racer, for Osborne College; F. R. Pendleton, to the St. George; E. B. Scott, to the Pembroke, additional for the Africa, appointment to the Antrim cancelled; J. F. Bell, to the Antrim, on commissioning; F. F. May, to the Victory for the Recruit; O. A. Morris, to the Victory for the Bullfinch; S. G. Misselbrook, to the Victory for the Dove; and W. H. Ham, to the Sapphire for the Kestrel, all on recommissioning.

Sub-Lieutenant: E. J. Connors, to the Formidable.

THE Mexican Minister of Communication and Public Works has granted the concession for ninety-nine years of a railway from Mexico to Puebla, *viâ* Ayapango Amecameca, Parage, Pelagalindas, Xalixnitla, San Nicolas, and Cholula. In the State of Mexico two lines, together 200 kiloms. (= 125 miles) long, and starting from Toluca, are projected, one to the boundary of the Morelos State and the other to effect junction with the Cuernavaca Railway. The company which has acquired the Popocatapetl volcano is considering the construction of a monorail line from a point near Llamacas to the summit, taking advantage of the most favourable slopes.

THE following particulars concerning the submarines and submersibles in the French navy are given in the *Moniteur de la Flotte*. There are forty-eight submarines of ten different types—namely, one of the Gymnote of 30 tons, one of the Zédé of 270 tons, three of the Morse of 140 tons, four of the Farfadet of 200 tons, twenty of the Naïade of 70 tons, one each of X, Y, and Z of 165, 225, and 213 tons, six of the Emeraude of 450 tons, and ten of the Guêpe of 45 tons. Of submersibles there are ten of five different types—namely, one of the Narval of 117 tons, four of the Sirène of 157 tons, two of the Aigrette of 177 tons, two of the Nuovi of 350 tons, and one of the Omega of 300 tons. These numbers include those which have been ordered.

THE Committee which will meet in St. Petersburg in a few days to consider projects for the construction of new lines of railway will have to consider a project for laying down a railway specially intended for goods traffic between St. Petersburg and Slavyansk, in the Kharkov Government of Central Southern Russia. A great deal has been said by the Russian Press of late with regard to driving English coal out of the Russian market, and the projected line of railway in question is to be an important factor in keeping English coal out of Russia. According to the project the new railway will be able to carry one pood of 36 lb. weight of coal from the Donetz coalfields to St. Petersburg, a distance of nearly 1000 miles, for 5½ kopecks, or about five and a-half farthings, instead of the rates now charged, which are 14½ kopecks, or rather more than 3½d. per 36 lb. It is claimed that the new rate of 7s. 2½d. per ton will not entail any loss upon the railway, and that if the railway is built, Russian coal will become very much cheaper than English coal, and the Russian market will be made independent of English coal and of its variations in price. The projected railway would be built in almost a due southerly direction right through the middle of European Russia.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, June 20th.

THE accumulation of business on the books of western builders of machinery is stimulating inquiry once more for a good deal of pig iron for delivery during the summer and autumn months. To-day there are buyers in the market for 30,000 tons of basic and 25,000 tons of foundry. Both the basic and foundry consumers find it necessary to reappear in the market and protect themselves by contracts which will call for delivery up to as late as October. A good deal of special analysis iron is now wanted, some of it calling for 2½ to 3 per cent. silicon iron. The Eastern Bar Iron Association holds its meeting on Thursday at the Waldorf Astoria Hotel in this city, but it is believed that the present range of prices will be adhered to. Several large contracts for structural and fabricated material have been placed within a few days, and inquiries now pending for shapes and plates and material for railroad business, which will crowd the facilities of the structural mills to their utmost. Nearly all the railroad companies are in the market for larger or smaller quantities of structural material. The largest single order placed this week was by a Milwaukee concern, who contracted with a Pittsburg concern for 3500 tons of steel to be used in the extension of a large engineering plant in Wisconsin. The West Shore Railroad has just placed a contract with the American Bridge Company for 125 small bridges, the material for which is to be furnished between now and October 1st.

There are negotiations pending to-day for 60,000 tons of structural material, not including the 55,000-ton order for the new Manhattan Bridge. Within the past few days the Illinois Central Railroad contracted for 10,000 tons; the Cincinnati, St. Louis, 6000 tons; the Chicago and Alton, 3000 tons; the Buffalo, Rochester, and Pittsburg, 3000 tons; and Cleveland Traction Companies, 6000 tons. The Japanese Government has recently contracted for 900 steel box cars with the Pressed Steel Car Company, in addition to 1000 cars from the American Car and Foundry Company. The Panama Canal Commissioners have ordered 24 locomotives, 500 freight cars, and six passenger cars.

The copper market is quiet, continental smelters having withdrawn. The Chinese interests are doing nothing at present. Electrolytic copper is selling at 15 cents, and the copper people think that this price will hold during the summer. The exports of copper from Atlantic ports for the first thirteen days of June were 9986 tons. It is estimated that the exports of copper for the first six months will be 15,000 tons more than for the first six months of last year. Speculative influences in London are the reported cause of some slight advances in tin in this market. Sales were made recently at 30·45. There is a fair demand for all grades of pig lead at 4·50, and soft Missouri brands at 4·42½; spot supplies of spelter are being offered at 5·35. Aluminium is steady at 33 cents; quicksilver at 38 dols. per flask. The tone of the entire market is quite strong, and an exceptionally active summer season in all lines is in sight.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. EDWARD WHITE, of Windsor Works, Redditch, informs us that he has purchased the patent rights of Mr. C. W. Coleman for his invention of pattern plate apparatus, and will now manufacture the apparatus at Redditch. Mr. W. Littleton, of 9, Fenchurch-street, London, E.C., has been appointed sole agent for London and the South of England.

THE address of Messrs. Wood and Crawford is now 86, Queen-street, Sheffield. The firm has recently obtained the sole right of manufacture of Ford's patented heating furnace.

MESSRS. NALDER BROTHERS AND THOMPSON, Limited, notify us that in future Mr. Ernest Roberts, 6, Holborn-place, who heretofore has had charge of their London district travelling, will not act in this capacity in future owing to the large increase in his own business. Any inquiries which he may receive will be attended to as heretofore. Messrs. Frampton, Paine and Jackson, 29, Old Queen-street, Westminster, will in future represent them in London, and likewise in the Southern, Western, and Eastern Counties, and those districts where they are not at present represented.

THE INSTITUTE OF SANITARY ENGINEERS, LIMITED.—The following meetings have been arranged:—July 5th, election committee at 3.30 p.m.; organising committee at 5 p.m. July 19th, examination and literary committee at 3.30 p.m.; finance committee at 5 p.m.

THE GOLD PRODUCTION of the United States in 1904 is reported to have been £16,910,800. This is due partly to gains, in Cripple Creek; in California, in dredging; in Utah, in smelting auriferous copper; and to the new producer of Goldfield, Nevada.

REPLYING TO A WRITTEN QUESTION by Mr. Fenwick regarding the amount received from the coal tax in the various ports of the United Kingdom, the Chancellor of the Exchequer states that during the year 1904-5 the following sums were received:—Bristol Channel, £850,923; North-Western ports, £17,066; North-Eastern ports, £669,847; Humber ports, £157,272; other East Coast ports, £14,924; other English ports, £129; total for England, £1,710,161. Ports on the East Coast of Scotland, £265,837; ports on the West Coast of Scotland, £76,767; total for Scotland, £342,604; Irish ports, 9. The total for the United Kingdom is £2,052,774, as against a total of £2,051,653 in the year 1903-4, £1,991,767 in 1902-3, and £1,311,706 in 1901-2.

CONTRACTS.—Andrew Barclay, Sons and Co., Limited, Caledonia Works, Kilmarnock, have received orders from the Tarbrax Oil Company, Glasgow, for motor-driven Capell fan to deliver 100,000 cubic feet of air at 3in. w.g., as well as a pump for 600 gallons per minute against a head of 400ft.; from Pearson and Knowles Coal and Iron Company, Wigan, three-throw pump; Arch. Russel, Limited, Hamilton, Capell fan and engine; Young's Oil Company, Glasgow, 20in. winding engines; from Connal and Co., Limited, Middlesbrough, 14in. loco.; Cargo Fleet Iron Company, Limited, Middlesbrough, 16in. loco.; and Wm. Beardmore and Co., Limited, Glasgow, for locomotives.—The Great Western Railway Company has placed with Kerr, Stuart and Co., an order for twelve steam railway saloons 170ft. long, which order is said to be the largest yet placed for these coaches, and is the second order which Kerr, Stuart and Co. have received from this railway. The same firm have also secured an order from the Buenos Ayres and Pacific Railway Company, for six powerful shunting engines, 5ft. 6in. gauge.—The Stirling Boiler Company, Limited, have received orders for two Stirling boilers with superheaters and chain grate stokers, each boiler to evaporate 18,900 lb. of water per hour, for the Edinburgh Corporation, and two Stirling boilers, each to evaporate 7000 lb. of water per hour, complete with piping, chimney, and feed pumps, for the Bournemouth Gas and Water Company.—Kennicott Water Softener Company has received an order from the Societa Generale Italiana Edison di Elletricita, of Milan, for a water softener capable of dealing with 40,000 gallons per hour, and an order from the South Australian Government Railways for a water softener capable of dealing with 2000 gallons of water per hour.—Messrs. Mackay Brothers, Alloa, have received an order for a 600-ton deadweight steamer for English owners.—Messrs. Bruce, Peebles and Co., Limited, have recently received contracts aggregating 6000 horse-power from the Lambton, Risca, and Bow Hall Collieries, and from Darbishes Quarries, for machinery for pumping and hauling, &c.—Two Stirling boilers fitted with chain grate stokers, each to evaporate 18,500 lb. of water per hour, have been ordered from the Stirling Boiler Co., Limited, for the Kirkcaldy tramways and electric light station.

CATALOGUES.

PARKER BOILER COMPANY, Pennsylvania-building, Philadelphia, —The Parker steam generator described in this brochure is of the horizontal water-tube type with a strong non-reversible flow, which tends to prevent burnt tubes. The details of construction are clearly shown.

WELLMAN-SEAVER-MORGAN COMPANY, Cleveland, Ohio. —An unusually handsome catalogue by this firm is devoted exclusively to ore and coal-handling machinery. A supplementary section deals with excavating appliances and illustrations of the company's works in America are also given.

JOHN HANDS AND SONS, Cardigan Works, Belmont-row, Birmingham.—This brochure deals with presses, several varieties of which are shown, including single type power, duplex type power, and open back power presses. Tables of useful information and dimensions are given with each illustration.

T. RYDER AND SON, Turner Bridge Ironworks, Bolton.—The Ryder forging machine described in this tasteful pamphlet, as most engineers are aware, is a swaging machine delivering 800 to 1000 blows per minute. The illustrations show the different patterns that are made, and also a hot-sawing machine.

RICHARD HORNSBY AND SONS, Limited, Grantham.—A very neat pamphlet has been circulated by this firm entitled "Light and Power in the Country House." The object of the book is to set forth the advantages of the Hornsby oil engine, and this is done very effectively. There are some well produced illustrations of country house installations.

W. SUMMERSCALES AND SONS, Limited, Keighley.—Catalogue No. 673 treats of laundry and cooking appliances, and serves incidentally to demonstrate the immense strides that have been made in late years in these branches of the engineering trade. The brief descriptions and illustrations have necessitated a book of over 150 pages, which will be found useful to those interested in these trades.

ARTHUR L. GIBSON AND CO., 19, 20, and 21, Tower-street, Upper Saint Martin's-lane, London.—The new edition of this firm's illustrated catalogue deals chiefly with the Kinnear patent steel rolling shutter, and many illustrations are given showing the extent to which the shutter has been adopted in this country. The construction of the shutter is also illustrated in detail, together with the different arrangements and methods of attachment adopted to suit actual conditions.

WM. R. DELL AND SON, 26, Mark-lane, London, E.C.—"Rice Mill Machinery suitable for Large and Small Mills" is the title of this firm's new catalogue, Section D. Messrs. Dell devoted themselves to the production of high-class machinery for rice mills for many years, and a few years ago purchased the patterns of the late firm of Whitmore and Binyon, who had supplied many large plants to Siam and the Far East, so that they have now a highly complete line of machinery for this purpose.

LAUNCHES AND TRIAL TRIPS.

ARCHBANK, steamer; built by, Messrs. Furness, Withy and Co; to the order of, the Peareth Steamship Company, Limited; dimensions, 350ft.; engines, triple-expansion, 24in., 39in., 66in. by 45in., pressure 180 lb.; constructed by, Richardsons, Westgarth and Co.; speed averaged 11¼ knots; trial trip, June 15th.

APOLLO, steel screw steamer; built by, Furness, Withy and Co., Limited; to the order of, Messrs. Harris and Dixon; dimensions, 350ft. and cubic capacity 339,936; engines, triple-expansion, 24in., 39in., 66in. by 45in., pressure 180 lb.; constructed by, Richardsons, Westgarth and Co.; launch, June 17th.

MAHRONDA, steel screw steamer; built by, Messrs. Harland and Wolff; to the order of, Messrs. Thomas and John Brocklebank, Limited; dimensions, 470ft., 58ft.; to carry, 11,000 tons deadweight; engines constructed by, builders; launch, June 17th.

SANTA CRUZ, steel screw steamer; built by, Swan, Hunter and Wigham Richardson, Limited; to the order of, Hamburg-Sudamerikanische Dampfschiffahrts-Gesellschaft; dimensions, 405ft., 50ft. 3in. by 31ft; engines, triple-expansion, 25½in., 43in., 74in. by 48in., pressure 200 lb.; constructed by, Wallsend Slipway and Engineering Company; launch, June 17th.

TIBERIUS, finely moulded steamer; built by, Northumberland Shipbuilding Company, Limited; to the order of, Mr. C. Anderson, Hamburg; dimensions, 372ft., 48ft. by 30ft. 10in.; to carry, 7000 tons; engines, triple-expansion, 26in., 42in., 72in. by 48in., pressure 180 lb.; constructed by, North-Eastern Marine Engineering Company; launch, June 17th.

VIGO, steamship; built by, Earle's Shipbuilding and Engineering Company; dimensions, 336ft., 48ft. 3in. by 25ft. 4in.; engines, triple-expansion, 20in., 32in., 54in. by 42in., pressure 195 lb.; a mean speed of 10½ knots was attained; trial trip, June 17th.

RHEINFELS, steel screw steamer; built by, Swan, Hunter and Wigham Richardson, Limited; to the order of, The Deutsche Dampfschiffahrts Gesellschaft; dimensions, 420ft. by 55½ft.; to carry, 8000 tons deadweight; engines, quadruple; constructed by, builders; launch, June 19th.

LEAFIELD, steel screw steamer; built by, Messrs. Wood, Skinner and Co.; to the order of, Mr. Alfred Brewis; to carry, 4350 tons deadweight; engines, triple-expansion, 23in., 37½in., 61½in. by 39in., pressure 180 lb.; constructed by, North-Eastern Marine Engineering Company; on the measured mile the trial was highly satisfactory; trial trip, June 21st.

WESTLANDS, steel screw steamer; built by, Wm. Gray and Co., Limited; to the order of, Messrs. Joseph F. Wilson and Co.; dimensions, 342ft., 47ft. 6in. by 24ft. 9in.; engines, triple-expansion, 24in., 38in., 64in. by 42in., pressure 180 lb.; constructed by, builders; everything gave satisfaction, and an average speed of 11½ knots was attained; trial trip, June 21st.

CAMBYSES, steel screw steamer; built by, Wm. Gray and Co., Limited; to the order of, the Gladstone Steamship Company, Limited; dimensions, 361ft. 6in., 46ft. by 26ft. 1in.; engines, triple-expansion, 24½in., 40in. and 65in. by 42in., pressure 180 lb.; constructed by, builders; an average speed of 13 knots was attained; trial trip, June 23rd.

PURUNI, steamship; built by, Swan, Hunter and Wigham Richardson, Limited; to the order of, Messrs. Sprostons, Limited, Demerara; dimensions, 147ft., 24ft. 6in. by 9ft., to carry, passengers and cargo; engines, triple-expansion, 9½in., 15in., 25in. by 18in., pressure 180 lb.; constructed by, A. G. Mumford, Limited, Colchester; a speed of 10½ knots was attained; trial trip, June 23rd.

AEON, steel screw steamer; built by, Northumberland Shipbuilding Company; to the order of, Messrs. Howard Smith and Co., Limited; dimensions, 372ft., 48ft., 30ft. 10in.; to carry, 7000 tons deadweight; engines, triple-expansion, 25in., 41in., 69in. by 48in., pressure 180 lb.; constructed by, Richardsons, Westgarth and Co.; a speed of 11½ knots was attained.

THE amended scheme for the new outfall sewage works has been accepted by the Drainage Committee of the Maidstone Corporation. The estimated cost for the work is £83,000. The loan has been granted on the following terms:—For the land £6500, spread over a term of 60 years; for laying mains, pipes, &c., £71,394, 30 years; machinery, £5146, 15 years. The beds for the surface water are now to be 6000 yards by 3ft. deep, and those for the sewage 6000 yards by 9ft. deep.

BRITISH PATENT SPECIFICATIONS.

Selected and Abridged by JAMES D. ROOTS, *M.I. Mech. E.*

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-Office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-Office of opposition to the grant of a Patent.

GAS ENGINES.

11,564. May 19th, 1904.—IMPROVEMENTS IN PORTABLE ENGINES, *Joseph Delassue, 7, Rue Thorel, Paris.*

This invention relates to portable engines for suction gas. There are four figures, of which Fig. 1 is a longitudinal section of a suction gas engine. *c* is the gas generator surmounted by a charging box *d*. Behind the generator a coke column is mounted, and is surmounted by the box *f* containing fibrous material for completing the purification of the gas. A fan *g* serves for starting and subsequently for producing the circulation of the cooling air. The cooler consists of a vertical reservoir *l* arranged in front of the carriage provided with two series of tubes, the inner series *m* being in communication at its lower part with a box *n*, which receives air coming from the fan. The second series of tubes *o* opens at the lower part outside the reservoir *l*, and at the upper part a little below the upper orifices of the tubes *m* within the nozzle *p*. An air draught is produced by induction in this second series of tubes, thereby completing the cooling of the water, which leaves the motor and passes to the upper part of the reservoir *l*, and descends in cooling, and then reaches a reservoir *q* arranged beneath the frame, from which it passes into the cylinder casing and recommences its circuit. A pipe *r* is axially arranged in the reservoir *l*, and is connected at its upper end with a pipe *s* from the generator. The gas, after having become cooled, is received by a pipe *t* leading to the coke column and the box *f*, from which it passes to the motor through *u*. A three-way cock *v* connects the fan *g* with the pipe *t* during the starting period. When, after having closed the communication of the fan with the generator, the motor is started, the cock *v* is arranged to permit the fan to draw in the outer air and to drive into the tubular assemblage of the cooler.—*June 1st*, 1905.

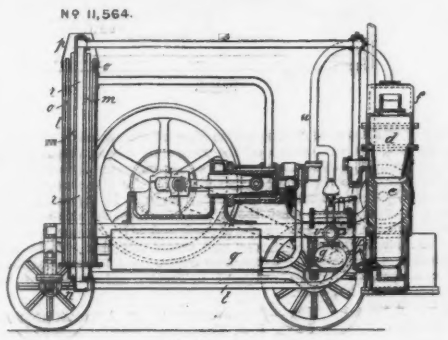


Fig. 1.

PRIME MOVERS.

9125. April 20th, 1904.—A METHOD AND APPARATUS FOR UTILISING BOTH INTERNAL COMBUSTION AND STEAM IN PRIME MOVERS.—*T. Schtcherbakoff, Building of the Varvarinsky Company, Limited, Ostojenca, Moscow.*

The method of utilising the heat of combustibles forming the object of this invention consists in combining the method in which combustion vaporises liquids and the vapour so formed expands in the cylinder with the method in which the products of combustion themselves expand in the cylinder. Apparatus for carrying out the method is illustrated by eight figures, of which Fig. 1 is a section of combined boiler and combustion chamber, and of a gas and steam motor. The combined boiler and combustion chamber consists of the combustion tube A and the casing B surrounding the latter. The casing B contains water. The tube A is provided with a discharge pipe A^1, which is provided with a conical valve *k* for adding steam drawn from the boiler to the products of combustion. The lower end of the chamber A has an extension A^{11}, containing three injectors *a*, *b*, *c*, for the admission of combustible, air, and steam, respectively, at a pressure of five atmospheres and upwards. The casing B communicates with a steam collector B^1 surrounding the discharge pipe A^1. The injectors *a*, *b*, *c*, are connected by means of piping, not shown, the first with a reservoir of liquid, gaseous, or pulverulent combustible, the second with a compressor or reservoir of compressed air, and the third with the steam collector. The combustion which takes place in the tube A serves both for vaporising the surrounding water and for expanding the gaseous mixture of products of combustion with steam, which mixture has a temperature above 300 deg., and serves for feeding the motor having a single cylinder C, the walls of which require no refrigeration, but have a steam jacket and an insulating covering.—*June 1st*, 1905.

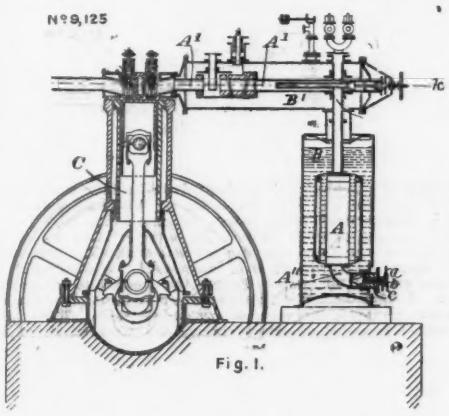


Fig. 1.

GAS PRODUCERS.

9606. April 27th, 1904.—IMPROVEMENTS IN OR RELATING TO GAS-PRODUCER PLANT, Charles Whitfield, Anglezarke, Kettering.

These improvements refer particularly to suction gas-producer plant. There are three figures, of which Fig. 1 is an elevation of a gas-producer suction plant embodying the invention. A is the producer. B is the ashpit, which is entirely closed save for a pipe C leading to the atmosphere, and a pipe D leading from the air saturator U. Through the branch G moisture from the newly fed fuel may be drawn and used with the air in working the producer. The gas outlet H is joined by the pipe I to the cooler J, through which the hot gas passes, and by the water in which it is cooled. The scrubber K dips at its lower end into the tank M filled with water. N is the outlet pipe through which gas is drawn by each charging stroke of the engine. By this arrangement each withdrawal of gas from the interior of the scrubber, instead of causing a rarefaction of the gas remaining in the scrubber, tends to create a partial vacuum, and thus causes the water to rise. Each withdrawal has little effect on the gas flowing from the producer or the air passing to the producer. The water forming the seal gradually sinks and causes the introduction into the scrubber of fresh gas,

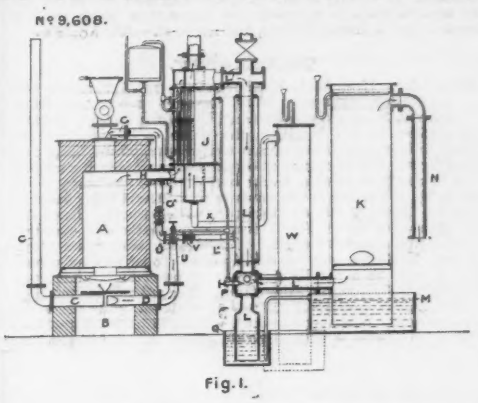


Fig. 1.

and thus acts as a compensating piston, so that at all times the gas in the apparatus is of approximately uniform density and conforms more closely to the conditions of the gas in a plant working under pressure. To further compensate for the withdrawal of the gas, the lower end of the pipe L may open into a tank Q and be water-sealed. The saturator U is fitted with an ejector and through a chamber U^x connects, on the one hand, with the atmosphere and, on the other hand, with the upper part of the producer through pipe G^x. With the ejector at work air and vapour mixed with steam are drawn through the pipe D, the end of which is contracted and lies opposite the wider and open end of the pipe C, so that in issuing from the pipe D the saturated air is free to pass up or be drawn into the producer after each withdrawal of gas from the scrubber, whilst when not so drawn it is free to pass away through the pipe C into the atmosphere. Should the supply of air to the producer be insufficient, air is admitted through the pipe C, the producer being thus at all times supplied with only the right amount of air. The air supplied to the saturator may be drawn from the atmosphere through a valve V or from an open-ended superheater L^x. W is an additional scrubber sometimes employed.—*June 8th*, 1905.

ORDNANCE.

15,220. July 7th, 1904.—IMPROVED MANUFACTURE OR TREATMENT OF ARMOUR PLATES AND OTHER ARTICLES OF STEEL, Robert Abbott Hadfield, Parkhead House, Sheffield.

The object of this invention is to increase the toughness of steel, especially nickel chromium steel, whether containing tungsten or not. The article to be treated, for example a cast armour plate, is heated uniformly to a temperature of from about 950 deg. Cent. to 1100 deg. Cent. and then cooled, preferably in air, which avoids sudden cooling. It is then reheated to about 700 deg. Cent. and cooled slowly, preferably in the furnace, after which it is again heated to about 700 deg. Cent. and allowed to cool slowly to about 640 deg. Cent., whereupon it is suddenly cooled as by quenching in water. It is then reheated to about 600 deg. Cent. and again suddenly cooled as before, preferably by quenching in water. The first-mentioned reheating to about 700 deg. Cent., followed by slow cooling, may be omitted. Steel treated as described is also capable of successfully withstanding excessive vibrating shocks, and is therefore adapted for the construction of parts of machines.—*June 1st*, 1905.

16,127. July 20th, 1904.—IMPROVEMENTS IN SIGHTING GEAR FOR GUNS, Sir W. G. Armstrong, Whitworth and Co., Limited, Elswick Works, Newcastle-upon-Tyne, and Saxton William Armstrong Noble, 8, Great George-street, Westminster.

This invention relates to sighting gear, in which the angle of the line of sight is converted into a reading of yards range on a graduated scale, disc, drum, or like device, suited to a given velocity of projectile. According to this invention, means are provided for making this reading or index correct for the range when the velocity of the projectile is decreased or increased by the varying temperature of the gases of the explosive or by the leakage of part of those gases due to erosion or any defect of the gun or powder. The sighting mechanism is constructed in such a manner that the angle through which the sighting line or telescope has to be shifted to set it into position for any given range, according to the indicating scale, can be increased or decreased according as the muzzle velocity is low or high. There are eleven figures, of which Fig. 1 shows a side elevation of the improvement applied to a trunnion or cradle sight mechanism, in which a telescope or sighting line is

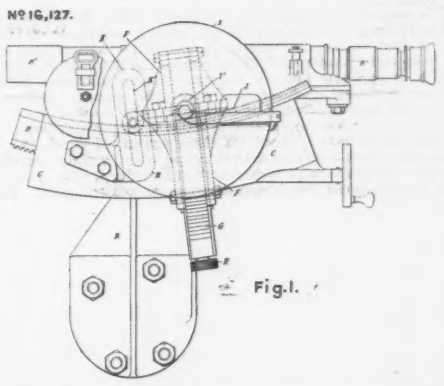


Fig. 1.

carried by a guided arc, capable of being moved around an imaginary centre above the central line of the gun. B is a bracket secured to one of the trunnions, and carrying a curved guide C. D is an arc sliding in this guide. The arc is provided with teeth on its under side, with which gears a worm, controlled by a small hand wheel E. A telescope D^1 is carried by the arc D. Usually the turning of the hand wheel revolves a drum or disc, registering the relative movement of the arc in its guide. In place of this, movement is given to the drum through a toothed arc, which can be set nearer to or farther from the point from which the curved arc D is struck, so that the movement of the drum relatively to that of the arc may be increased or decreased. To do this the arc has fixed to it a straight radial guide F, along which a slide G can be moved up and down. The slide G carries the pivot of the range dial I, and has a scale marked upon it for muzzle velocity, and can be raised or lowered by turning the screw H. I^1 is a pinion, fast with the range dial and gearing into the second rack J. This rack is coupled to a pin, which can move in a slot K^1, formed in a bracket K. When the arc D is shifted endwise, the range dial is turned in one or other direction by the pinion I^1, and the turning movement depends upon whether the pinion of the range dial has been set into one of its upper or lower positions. In the drawings it is shown in central position between highest and lowest muzzle velocities. If velocity of shot falls, and decreases the range, the dial must be made to approach the centre from which arc D is struck to give a shorter reading, and *vice versâ*.—*June 1st*, 1905.

TELEGRAPHY.

13,736. June 17th, 1904.—IMPROVEMENTS IN APPARATUS EMPLOYED FOR MEASURING WAVE LENGTHS IN WIRELESS TELEGRAPHY, John Ambrose Fleming, University College, London.

According to this invention, the waves to be measured are caused to induce other waves in a coil of wire, means being provided for varying the operative length of this coil in such a manner that, as nearly as possible, one or more complete stationary waves are set up, the length of the waves to be measured being deduced from the length of the coil required for this purpose. There are two figures, of which Fig. 1 is a diagrammatic side elevation showing the apparatus applied to a wireless telegraphic transmitter. K^1 K^2 is a long fine silk-insulated copper wire coil wound in one layer on a rod K^3 of ebonite or other highly insulating material; e^1 e^2 e^3 are insulating stands. The rod may be 3 m. long. C^1 is a small air condenser connected, as shown, to K^1 and to the aërial wire A. D is a metal saddle padded with tinfoil and connected by a wire w with an earth plate E^2. The transmitter

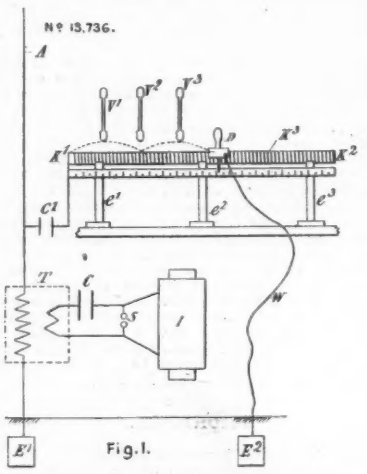


Fig. 1.

shown is an induction coil I with a spark gap S. The spark balls are connected by a condenser C and by the primary coil of an air core transformer T, the secondary circuit of which is inserted between the aërial wire A and an earth plate E^1. To determine the frequency a vacuum tube filled with rarefied neon, for example, is employed, the glass being made fluorescent by being impregnated with uranium. The oscillations in the wire A set up stationary electric waves in the helix, which are reflected at the saddle D. If K^1 D be equal to one complete wave length of a stationary wave upon the helix, then if the vacuum tube be held at a point V^2 half-way between K^1 and D it will not be illuminated, whereas if held at points V^1 or V^3 it will be brightly illuminated. If D be placed at any other position which is not an exact wave length or multiple, then the vacuum tube will either glow or not glow irregularly in any position. By means of the following equation the wave length (A) of the waves emitted by the aërial can be calculated:—If λ be the observed stationary wave length on the helix, c the capacity per unit of length of the helix with respect to the earth, and l the inductance per unit of length of the helix,

$$A = 1{,}000{,}000{,}000\ \lambda\ \sqrt{c\,l}\ \text{feet.}$$

—*June* 1st, 1905.

MISCELLANEOUS.

14,249. June 23rd, 1904.—IMPROVEMENTS IN OR CONNECTED WITH PERCUSSIVE ROCK DRILLS, A. H. Gibson, 44, Bushwood-road, Kew.

This apparatus is intended for use in rock drills where a piston and cylinder, working near to the drill proper, reciprocate air in a pair of pipes, whose other ends are connected to the two ends of the rock drill cylinder, and thereby cause the piston of the rock drill to reciprocate without the use of any automatic valve gear or equivalent device on the rock drill proper. Hitherto these drills have usually had an automatic valve opening inwards at each end of the air compressor cylinder to supply additional air to allow for leakages. There are three figures, of which Fig. 1 represents a rock drill with the connecting pipes and pressor, the rock drill being shown in vertical section and the pressor cylinder with electric motor for driving the same in sectional plan. The

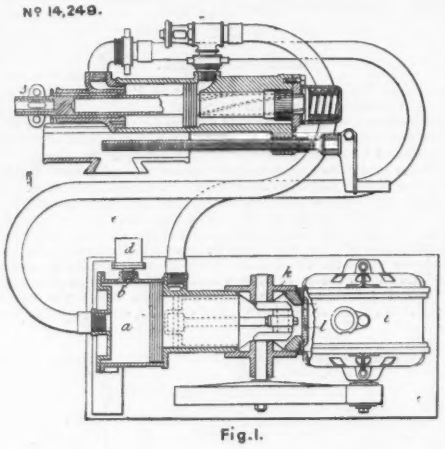


Fig. 1.

whole of the pressor is arranged as compactly as possible, and is made light enough to enable two men to transport it easily. Instead of arranging as hitherto a non-return air inlet valve at each end of the pressor cylinder, the cylinder a has an aperture b formed at about the centre of the stroke, and the non-return valve d is connected with this aperture. The valve d is cut off from the compression side of the piston during the heaviest part of the stroke, and so obviates leakage whilst it is open to the suction side of the piston during the latter half of the stroke, when any air necessary to supply loss due to leakage is sucked in. The construction of the pressor is specially designed to reduce shaking. The motor i and the pressor cylinder a are arranged on a base with the centre line of the pressor cylinder passing through the centre of the motor at a point near to the centre of gravity of the motor. The crank chamber k is secured rigidly to the electric motor i by means of the inter-connecting piece l, which is bolted to the motor body. In operation the energy to arrest and re-start the motor acts directly on the mass of the electric motor through the piece l, and as the motor is much heavier than the pressor cylinder and crank chamber, which are preferably of aluminium, the machine can be used on surfaces that are considerably inclined without noticeable inconvenience or shaking.—*June* 1st, 1905.

15,271. July 8th, 1904.—IMPROVEMENTS IN APPARATUS FOR BURNING LIQUID FUEL, J. J. Kermode, 62, Dale-street, Liverpool.

This invention relates to apparatus for burning liquid fuel, and the object is to provide a simple, cheap, and safe apparatus, in which the oil is heated before it enters the burner by exhaust steam from the oil pumping or other auxiliary engine. The essential feature of the oil heater is the arrangement which ensures an interchange of heat from the steam to the oil, protection being afforded by a body of water, which limits the temperature to 212 deg. Fah. There are four figures, illustrating three different forms of apparatus. Fig. 1 illustrates an arrangement in which the oil is filtered in the containing vessel, and is heated by a steam coil placed within the vessel. 1 is the containing vessel, which may be surrounded by a water jacket 1A, and which is divided into

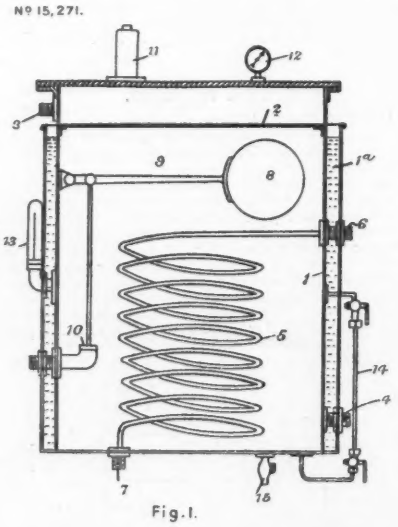


Fig. 1.

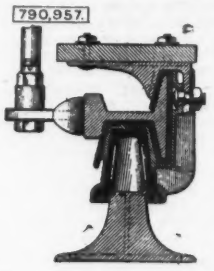
two parts by a diaphragm 2, which is adapted to filter the oil as it passes from the inlet 3 to the outlet 4. Within the vessel is a coil 5, through which steam passes, entering by the inlet 6 and leaving by the outlet 7. Within the vessel is fitted a float 8, carried on a lever 9, and operating an overflow valve 10, so arranged that when the normal oil level is exceeded the overflow 10 is opened and the oil escapes through the overflow to the supply tank. A relief valve 11 is fitted, which can be loaded to maintain the pressure within the vessel at any desired value. When this pressure is exceeded, air escapes through the relief valve and so relieves the pressure. A gauge 12, thermometer 13, water gauge 14, and drain 15 are fitted. The action is as follows:—Oil is supplied by the oil pumps to the inlet 3, and passes from the outlet 4 to the burner, being filtered and heated as it passes through the vessel, and also being maintained by the operation of the relief valve 11, which preserves a uniform pressure of the air in the top of the vessel at the desired pressure suitable for the burners.—*June* 1st, 1905.

SELECTED AMERICAN PATENTS.

From the United States Patent-office Official Gazette.

790,957. INSULATING SUPPORT FOR THIRD RAILS, *Ed. W. Farnham, Chicago, Ill.—Filed June 27th*, 1904.

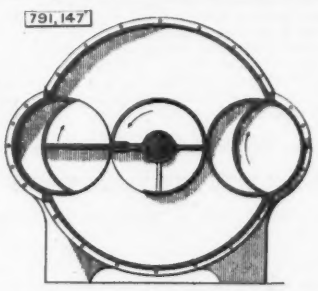
Little description of this support is necessary. It will be seen that a rail of the ordinary type is held sideways and is insulated



from its surroundings; the top plate is intended presumably to exclude rain and snow as well as to act as a safeguard.

791,147. ROTARY BLOWER AND EXHAUSTER, *T. W. Green, Philadelphia, Pa.—Filed January 7th*, 1905.

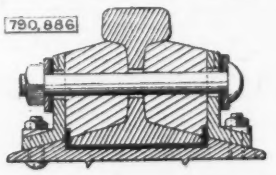
The action of this blower will be found an interesting puzzle. We give the first two claims "to make it more difficult." *Claim.*—1. In a device of the character described, the combination with two rotary locking members, of a third rotary locking member provided with a single locking blade, said blade and third locking member



being arranged to coact with said other locking members to form a lock. *Claim.*—2. In a device of the character described, the combination with two rotary crescent-shape locking members, of a third rotary locking member having a single blade adapted to sweep the inner surfaces of said crescent-shape locking members, all of said locking members adapted to coact to form a lock.

790,886. INSULATED RAIL JOINT, *S. S. Deemer, Reading, Pa.—Filed August 15th*, 1904.

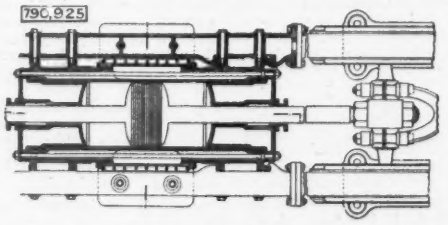
The section shows the construction of this joint quite clearly. The first claim is as follows:—A rail joint comprising a base-plate



having a central groove and a lining of insulating material within said groove, and fish-plates adjustably connected to said base-plate, substantially as shown and described.

790,925. CONSTRUCTION OF CYLINDERS FOR GAS ENGINES, *F. K. De la Saulx, Seraing, Belgium.—Filed March 30th*, 1904.

This is a design for a cylinder for gas engines of the Cockerill type. It includes a frame, two side frames bolted to the said



frame so as to form a support for the trough, an outer jacket for the cylinder, a cover for the trough, means for holding the cylinder in position within the trough, and suitable heads bolted to the cylinder.

END OF VOL. XCIX.

The Engineer.

Registered as a Newspaper

OFFICE FOR ADVERTISEMENTS AND PUBLICATION, 33, NORFOLK STREET, LONDON, W.C.

VOL. XCIX.—No. 2583] LONDON: FRIDAY EVENING, JUNE 30, 1905. PRICE SIXPENCE

India-office, Whitehall,
28th June, 1905.

The Secretary of State for

India in Council is prepared to receive TENDERS from such persons as may be willing to supply :—

BRIDGEWORK, 60ft. Spans.

The conditions of contract may be obtained on application to the Director-General of Stores, India-office, Whitehall, S.W., and Tenders are to be delivered at that office by Two o'clock p.m. on Thursday, the 6th July, 1905, after which time no Tender will be received.

E. GRANT BURLS,
Director-General of Stores.
2159

Ministry of Public Instruction,

EGYPT.
SCHOOL OF AGRICULTURE.

AN INSTRUCTOR in LAND SURVEYING and FARM ENGINEERING is REQUIRED to begin work on September 30th in the School of Agriculture, Ghizeh (near Cairo)

Preference will be given to candidates having experience of practice and teaching. They should be from 23 to 35 years of age, unmarried, and have a robust constitution.

A University Degree or College Diploma is an essential qualification.

Salary about £325 per annum (£ Eg. 24 per mensem), rising to about £395 per annum (£ Eg. 32 per mensem). Allowance for passage out to Egypt. Bachelor quarters are provided.

Applications, with full statement of qualifications, and accompanied by copies only of testimonials, must be sent in before July 22nd, 1905, addressed to W. C. MACKENZIE, Esq. D.Sc., 5, The Crescent, Cromer, to whom candidates may apply for further information. 2032

Ministry of Public Instruction,

EGYPT.
POLYTECHNIC SCHOOL OF ENGINEERING.

AN INSTRUCTOR in ENGINEERING is REQUIRED, to begin work on September 30th, in the Polytechnic School of Engineering, Ghizeh (near Cair.)

The Instructor appointed will be engaged in teaching Descriptive Engineering and Hydraulics.

Candidates must have had practical experience as engineers, and have been engaged on work of a class intimately related to the subjects to be taught. They should be from 25 to 35 years of age, unmarried, and have a robust constitution.

A University Degree or Diploma in Engineering is an essential qualification.

Salary about £430 per annum (£ Eg. 35 per mensem), rising to about £553 per annum (£ Eg. 45 per mensem) Allowance for passage out to Egypt. Bachelor quarters are provided.

Applications, with full statement of qualifications, and accompanied by copies only of testimonials, must be sent in before July 22nd, 1905, addressed to W. C. MACKENZIE, Esq., D.Sc., 5, The Crescent, Cromer, to whom candidates may apply for further information. 2033

The Governors of the Woolwich

POLYTECHNIC invite APPLICATIONS for the following APPOINTMENTS, which will date from next September :—

1. One Teacher for ENGINEERING Subjects at a commencing salary of £150 per annum
2. One Teacher (Evening Classes only) for BUILDING CONSTRUCTION, BUILDERS' QUANTITIES, &c.

Further particulars of the above appointments may be obtained by sending to the Principal a stamped addressed foolscap envelope.

The last day for receiving applications is Friday, 14th July.

A. J. NAYLOR,
Clerk to the Governors
2075

East Surrey Water Company.

SALE OF ORDINARY SHARES BY TENDER.

Notice is hereby given that it is the intention of the said Company to SELL by TENDER ONE THOUSAND ORDINARY SHARES of £10 each (f and in the East Surrey Water Company.

The last day for the reception of Tenders will be Friday, the 28th day of July next, at 12 o'clock at noon.

Forms of Tender, with particulars of sale and conditions of Tender attached, can be had upon application at the Company's Office, Redhill, Surrey.

By order,
A. E. CORNEWALL-WALKER,
Secretary.

Redhill, Surrey,
23rd June, 1905. 2154

Borough of Douglas.—Completion

OF WEST BALDWIN RESERVOIR WORKS.
FOR SALE.

The Water Committee are prepared to receive OFFERS for the undermentioned PLANT :—

1 and 2 c.y. Tipping Wagons.
Two Hand Cranes, to lift 3 tons.
20 lb., 56 lb. and 60 lb. Rails, Fastenings, Crossings, &c.
One Circular Saw Bench and Saws.
Three Sets Shear Legs.
One Stonebreaker.
Three Locos., 3ft. gauge.
One 2 H.P. Ingersoll's Sergeant Drill complete.

Further particulars from Mr. F. Thorpe, Manager, Reservoir Works.

Offers, marked "Plant," to be forwarded to the undersigned. Offers to state price, delivery, and any other particulars that may be necessary.

ALEXANDER ROBERTSON,
Town Clerk.
2060

Borough of Lymington.—For

SALE.

The Lymington Town Council are DESIROUS of DISPOSING of :—

TWO of Donaldson's PATENT AUTOMATIC PUMPS, formerly used for pumping sewage at the Corporation Sewerage Works. The original cost of the pumps was £1,000.

Also ENGINE BOILER (Cornish type), proportioned for working safely under 60 lb. steam, and tested to 120 lb. of hydraulic pressure. The boiler is 9ft. 8in. diameter, and 11ft. 7½in. long.

The pumps and boiler can be seen at Lymington by appointment.

The highest or any Tender will not be necessarily accepted.

Offers for either the pumps or boiler, or both, should be submitted to me (endorsed on the outside "Tender") on or before the 10th July, 1905.

By order,
J. DAVIS RAWLINS,
Town Clerk.

Town Clerk's Office,
Lymington, 22nd June, 1905. 2115

City of Hull Waterworks.—To

WELL SINKERS.

The Hull Corporation are prepared to receive TENDERS for the CONSTRUCTION of WELLS, ADITS, and BORES at their Cottingham Pumping Station.

Copies of the specification and form of Tender may be obtained on and after 24th June, 1905, on payment of £2, which will be returned on receipt of a bonâ fide Tender.

The plan may be inspected between the hours of 10 a.m and 4 p.m. at my office, and the site of the works may be visited by appointment.

Cheques and postal orders to be made payable to Mr. T. G. Milner, the City Treasurer.

Tenders, endorsed "Tender for Adits, &c.," are to be addressed to the Chairman of the Water and Gas Committee, and delivered at the Town Clerk's Office, Town Hall, not later than Thursday, the 6th July, 1905.

The Corporation do not bind themselves to accept the lowest or any Tender.

F. J. BANCROFT,
Water and Gas Engineer.

Alfred Gelder-street,
21st June, 1905. 2038

Corporation of Leicester.

WATERWORKS
DERWENT SUPPLY MAIN, SECTION No. 1.
CONTRACT No. 1.
TO WATERWORKS CONTRACTORS.

The Water Committee of the Leicester Corporation are prepared to receive TENDERS for the EXECUTION of the WORKS required in the LAYING of MAINS, BUILDING of VALVE CHAMBERS, FIXING VALVE and other FITTINGS, TELEPHONE CABLES, and other work in connection with Section No. 1 of the Main for bringing the Derwent Supply to Leicester and for the Blackbrook Temporary Supply.

The approximate lengths of mains to be laid are as follows :—

4620 yards 32½ to 32½in. dia. cast iron pipes.	
490 yards 15in.	ditto
1840 yards 12in.	ditto
240 yards 6in.	ditto

Total 7470 yards, or 4¼ miles.

The drawings may be inspected at the offices of the Engineer, Mr. J. B. Everard, M. Inst. C.E., 6, Millstone-lane, Leicester, and conditions of contract, specification, quantities, and form of Tender obtained from him upon payment of £5, which will be returned upon the receipt of a bonâ fide Tender and of the conditions, specification, and priced quantities.

Sealed Tenders upon the form supplied, addressed to the Chairman of the Water Committee, Town Hall, Leicester, are to be delivered not later than Ten o'clock in the forenoon of Monday, the 17th day of July, 1905, endorsed "Tender for Laying Mains—Derwent Main."

The Corporation do not bind themselves to accept the lowest or any Tender.

E. V. HILEY,
Town Clerk,
Leicester.
June, 1905. 2063

Corporation of Leicester.

WATERWORKS.
DERWENT SUPPLY MAIN, SECTION No. 1.
CONTRACT No. 2.
TO PIPE FOUNDERS.

The Water Committee of the Leicester Corporation are prepared to receive TENDERS for the SUPPLY and DELIVERY of PIPES and SPECIALS required in connection with Section No. 1 of the Main for bringing the Derwent Supply to Leicester, and for the Blackbrook Temporary Supply, comprising :—

	Tons.	cwts.	qrs.	lbs.
32½in. Straight Socket Pipes..	339	1	1	14
32½in. do. do. ..	2575	7	2	0
34½in. do. do. ..	633	12	0	0
15in. do. do. ..	82	7	0	0
12in. do. do ..	210	19	3	7
6in do. do. ..	9	7	2	0
Special Castings	163	17	2	16
Total ..	4012	11	3	9

The drawings may be inspected at the offices of the Engineer, Mr. J. B. Everard, M. Inst. C.E., 6, Millstone-lane, Leicester, and conditions of contract, specification, quantities, and form of Tender, obtained from him upon payment of £5, which will be returned upon receipt of a bonâ fide Tender, and on the conditions, specification, and priced quantities.

Sealed Tenders upon the form supplied, addressed to the Chairman of the Water Committee, Town Hall, Leicester, are to be delivered not later than 10 o'clock in the forenoon of Monday, the seventeenth day of July, 1905, endorsed "Tender for Pipes—Derwent Main."

The Corporation do not bind themselves to accept the lowest or any Tender"

E. V. HILEY,
Town Clerk,
Leicester.
June, 1905. 2054

Corporation of Leicester.

WATERWORKS.
DERWENT SUPPLY MAIN, SECTION No. 1,
CONTRACT No. 3.
TO VALVE MAKERS.

The Water Committee of the Leicester Corporation are prepared to receive TENDERS for the SUPPLY and DELIVERY of No. 30, SLUICE VALVES, varying in size from 4in. to 30in. diameter, and No. 22, AIR, REFLUX, FLAP, and RELIEF VALVES required in connection with Section No. 1 of the Main for bringing the Derwent Supply to Leicester and for the Blackbrook Temporary Supply.

The drawings may be inspected at the offices of the Engineer, Mr. J. B. Everard, M. Inst. C.E., 6, Millstone-lane, Leicester, and conditions of contract, specification, quantities, and form of Tender obtained from him upon payment of £5, which will be returned upon the receipt of a bonâ fide Tender and of the conditions, specification, and priced quantities.

Sealed Tenders, upon the form supplied, addressed to the Chairman of the Water Committee, Town Hall, Leicester, are to be delivered not later than 10 o'clock in the forenoon of Monday, the seventeenth day of July, 1905, endorsed "Tender for Valves—Derwent Main."

The Corporation do not bind themselves to accept the lowest or any Tender.

E. V. HILEY,
Town Clerk,
Leicester.
June, 1905. 2056

County of London.—The London

COUNTY COUNCIL TRAMWAYS.
LINES SOUTH OF THE THAMES.
TO ENGINEERS, CONTRACTORS AND OTHERS.

The London County Council invites TENDERS for the ROADWORK and PLATE-LAYING required for the reconstruction for Electrical Traction on the Conduit System of the Tramways (a) from the authorised Tramways in Red Lion-street, via York-road, Battersea Park-road, Nine Elms-lane, Albert Embankment, and Lambeth Palace-road to Westminster; (b) along Lambeth-road; and (c) along Falcon-road; and for the EXECUTION of certain PAVING WORKS in connection therewith. The total length of the above-mentioned lines is about 12 miles single track.

The contractor will be required to use the track rails with their fastenings, the slot rails, and conductor rails which will be furnished by the Council under another contract, but all the remaining metal work and other materials, and all the special work at junctions, crossings, crossovers, &c., will be included in the contract.

Persons desiring to submit Tenders may, on and after Saturday, 1st July, 1905, obtain the drawings, specification, form of Tender, and other particulars at the Engineer's Department, County Hall, Spring-gardens, S.W., upon payment to the Cashier of the Council of the sum of £5.

This amount will, after the Council or its Committee shall have come to a decision upon the Tenders received, but not before, be returned to the tenderer, provided he shall have sent in a bonâ fide Tender and shall not have withdrawn the same, but in no case will the fee be returned unless a bonâ fide Tender is submitted.

Full particulars of the work may be obtained on application at the County Hall, previously to the payment of the fee for specification, &c.

Tenders must be upon the official forms, and the printed instructions contained therein must be strictly complied with.

The contractors will be bound by the contract to pay to all workmen (except a reasonable number of legally bound apprentices) employed by them wages at rates not less, and to observe hours of labour not greater, than the rates and hours set out in the Council's list, and such rates of wages and hours of labour will be inserted in and form part of the contract by way of schedule.

Each Tender is to be delivered at the County Hall, in a sealed cover, addressed to the Clerk of the London County Council, Spring-gardens, S.W., and marked "Tender for Roadwork and Plate-laying, L.C.C. Tramways."

No Tender will be received after 10 o'clock a.m. on Tuesday, 18th July, 1905.

Any Tender which does not comply with the printed instructions for Tender may be rejected.

The Council does not bind itself to accept the lowest or any Tender, and it will not accept the Tender of any person or firm who shall on any previous occasion have withdrawn a Tender after the same had been opened, unless the reasons for the withdrawal were satisfactory to the Council.

G. L. GOMME,
Clerk of the London County Council.
County Hall, Spring-gardens, S.W.,
30th June, 1905. 2166

Electrical Firms or Companies

are INVITED to COMMUNICATE immediately with the undersigned with the view of PROVIDING KILKENNY CITY with ELECTRIC LIGHT.

The Kilkenny Corporation obtained a Provisional Order, and might if necessary lease same for a term of years, and will pay £400 a year (or more) to any firm or company providing the light and supplying all plant, &c. Ample water power available within and outside the City

The population of Kilkenny is 10,500, valuation £18,000, and it has about 60 streets with 2500 houses.

For all details apply to—

R. J. GORE, C.E.
Town Hall, Kilkenny, 2028

Glasgow Corporation.—Gas

DEPARTMENT.
TO IRONFOUNDERS.

The Corporation of Glasgow invite TENDERS for the following QUANTITIES of CAST IRON PIPES, viz :—About 3085 yards of Pipes of 20in. diameter, and 3020 yards of Pipes of 20in. diameter, and also for Special Castings.

Copies of the specification and form of Tender may be obtained on application to Mr. Alexander Wilson, Gas Engineer, at his office, 45, John-street, Glasgow.

Sealed offers, marked "Gas Department—Tender for Cast Iron Pipes, &c.," addressed to the subscriber, will be received by him on or before Tuesday, the 4th proximo

The Corporation do not bind themselves to accept the lowest or any Tender.

JOHN BOWERS,
Town Clerk.
City Chambers, Glasgow,
24th June, 1905. 2123

Leeds Corporation Waterworks.

TENDERS FOR THE SUPPLY OF ABOUT
720 TONS OF 24in., 18in., AND 12in. OF
CAST IRON WATER PIPES AND
SPECIAL CASTINGS.

The Leeds Corporation invite TENDERS for the SUPPLY of CAST IRON PIPES and SPECIAL CASTINGS, to be delivered at Hunslet Goods Station, Leeds.

The forms of Tender and contract, with specification and schedule, may be obtained on application at the office of Mr. Chas. G. Henzell, the Waterworks Engineer, Municipal Buildings, Leeds, on payment by cheque of £2, which will be refunded on the receipt of a bonâ fide Tender.

Tenders, endorsed "Tender for Pipes for the Dewsbury Road Pipe Line," and enclosed in sealed envelopes, must be delivered not later than 10 a.m. on the 13th July, 1905, addressed to "The Waterworks Committee, Town Clerk's Office, Leeds."

The Corporation do not bind themselves to accept the lowest or any Tender. 2127

Merthyr Tydfil Urban District

COUNCIL.
REFUSE DESTRUCTOR PLANT.

The Council invite TENDERS from experienced makers of Refuse Destructor Plant for the ERECTION of PLANT capable of effectually burning 120 tons of refuse per day, together with all buildings and contingent works connected therewith.

The Council have selected three alternative sites, and copies of the site plans, together with "General Conditions and Particulars for the guidance of Contractors tendering," may be obtained upon application to T. Fletcher Harvey, Esq., Engineer and Surveyor to the Council, upon payment of a fee of £3 3s., which will be returned upon receipt of a bonâ fide Tender.

The Council do not bind themselves to accept the lowest or any Tender.

Sealed Tenders, endorsed "Destructor Plant," must be delivered to T. Aneuryn Rees, Esq., Clerk to the Council, on or before the 1st September, 1905.

T. FLETCHER HARVEY,
Engineer and Surveyor to the Council.
Town Hall,
Merthyr Tydfil,
16th June, 1905. 2111

Metropolitan Water Board.

TENDERS FOR THE SUPPLY OF 42in. AND OTHER SLUICE VALVES, PIPE CONNECTIONS, AND FITTINGS.

The Metropolitan Water Board invite TENDERS for the SUPPLY of 42in. and other SLUICE VALVES, with PIPE CONNECTIONS and FITTINGS, to be delivered at Cricklewood, in the County of London.

The forms of Tender and contract, with specification and schedule, may be obtained, and the drawings inspected, on application at the office of the Board, The Firs, Southern-road, Fortis Green, East Finchley, between the hours of 10 and 4 (except on saturdays) on and after Thursday, the 29th instant, on production of an official receipt for the sum of Ten Guineas, which must first be deposited with the Comptroller at the Board's Central Offices, Savoy-court, Strand, W.C., which sum will be returned after the receipt of a bonâ fide Tender.

Tenders, endorsed "Cricklewood Reservoirs Valves," enclosed in sealed envelopes addressed to the undersigned, must be delivered at the above-named Central Office, Savoy-court, Strand, W.C., not later than 12 noon on the 10th July, 1905.

A. B. PILLING,
Clerk of the Board.
2121

MOTOR OMNIBUS SPARE PARTS.

The London Road Car Company,

Ltd., will be GLAD TO HEAR from MANUFACTURERS of above.

Samples of crank shafts, pistons, pumps, radiators cylinders, sprockets, gear wheels, &c., can be inspected by appointment at the Company's Depôt, Seagrave-road, West Brompton.

Firms are only required to Tender for such parts as they make themselves, and their not tendering for all will not prejudice their securing the contract for part. 2133

To Boilermakers.—Tenders are

invited for the CONSTRUCTION and DELIVERY in London of a MARINE TUBULAR BOILER, 8ft. 9in. diameter, 9ft. long, to pass Lloyd's and Boiler Insurance survey for 120 lb. working pressure, 2 furnaces. Very quick delivery required.

Lowest or any Tender not necessarily accepted.

TOUGH and HENDERSON,
66, Upper Ground-street,
Blackfriars, S.E. P816

Corporation of Durban, Natal.—

APPLICATIONS are invited from Engineers to FILL the POST of BOILER SUPERINTENDENT in the Corporation Electric Power Station.

The candidate must have had charge of a large installation of boilers, not under 5000 horse-power, in a central electric works, and must be thoroughly experienced in the construction of water-tube boilers. He should have had experience of mechanical stokers; and preference will be given to one who has been accustomed to working with a CO_2 tester.

The successful applicant will be placed in entire charge of a large battery of boilers, under the direction of the Chief Works Engineer.

Salary offered is from £250 to £300 a year, depending upon the qualifications which can be shown.

Applications, endorsed "Durban Boiler Superintendent," stating age and experience, together with copies (not originals) of not more than three recent testimonials, to be delivered to the undersigned on or before Tuesday, 4th July, 1905.

WEBSTER, SPEEL and CO.,
Agents to the Corporation of Durban.
5, East India-avenue,
London, E.C.,
June 15th, 1905. 1986

Wanted, Assistant Used to

Drawing-office routine and able to get out quantities and lists of material.—State age and experience and salary required to 2130, Engineer Office, 33, Norfolk-street, Strand, W.C. 2130

Thame Urban District Council.

WORKING ENGINEER.

WANTED, a MAN capable of DRIVING and ATTENDING to Campbell's Oil Engines. Must be capable of Tapping Water Mains and Making Connections. One with previous experience preferred.

Applications, stating age, previous experience, weekly wages required, with copies of testimonials as to character and ability, to be sent to me on or before the 14th July next.

By order,
WILLIAM PARKER,
Clerk to the Council.
Council Offices,
2, High-street, Thame,
24th June, 1905. 2167

Wanted, a Good Trained En-

GINEER, who has had lengthy experience in the design of Modern High-speed Engines, to UNDERTAKE the POSITION of ENGINEER-ESTIMATOR in the Sales Department of one of the leading Engine Builders in Great Britain. He must be familiar with the existing methods of tendering for Corporation work and with specifications for private work.

He must also be accustomed to interviewing Consulting Engineers.

Address replies to H. H. LYDE, Esq., 33, Great St. Helens, London, stating age. 2000

Wanted, at Once in Kent, Resi-

DENT ENGINEER for Large Factory.

Must have good mechanical and electrical training, and be well up in running of steam and electrical plant (D.C. 500 volts.), and gearing; also used to control of men. Married man preferred.

Salary £2 0 with prospects.

Apply, by letter only, stating age and experience, to Box V.E., care of Glendenning and Co., Advertising Contractors and Agents, 90, Cannon-street, London, E.C. P763

A Manufacturing Company Deal-

ING in Metal Products REQUIRES a MANAGER competent to Take Control, under the Directors, of both Commercial and Manufacturing Departments. Age not to exceed 40. Salary to commence at £500 with prospects of considerable advance.—Address, with full particulars of experience, to 2109, Engineer Office, 33, Norfolk street, Strand, W.C. 2109

Assistant (Young Man) Required

in Cost Department of large Engineering Works in Midlands.—Write, "ENGINEERING," c/o. Bates, Hendy and Co., 81, Cannon-street, E.C. 2126

Civil Engineer for Chili.—Re-

QUIRED, young CIVIL ENGINEER to check road master, keep permanent way in order, survey short new lines if required, and to draw up estimates of costs.—Address, stating qualifications, experience, and salary desired, P877, Engineer Office, 33, Norfolk-street, Strand, W.C. P877

India.—An English Firm in One

of the Presidency Towns REQUIRES the SERVICES of a YOUNG MECHANICAL ENGINEER (age about 26, bachelor preferred).

One who has passed through shops and drawing-office and then taken up the commercial side.

Must have a good address and manner, and be accustomed to estimating, correspondence, accounts, &c.

Applications treated in confidence if desired.

Address, P736, Engineer Office, 33, Norfolk-street, Strand W.C. P736

Surveyor Required for Service

in the East; one accustomed to ordnance survey work preferred. Previous experience must be stated and highest references supplied.—Apply to Z. F. 356, c/o. Deacon's Advertising Offices, Leadenhall-street, E.C. 2132

Wanted, at Once, Junior

DRAUGHTSMAN for Temporary Work; must be a good tracer.—Apply (enclosing small sample of tracing), stating age, experience, and salary required, to R. L. 975, Deacon's, Leadenhall-street, E.C. 2163

Wanted for London Office, a

CAPABLE DRAUGHTSMAN, experienced in Refrigerating Work, Land and Marine.—Address, giving full details, with references, salary required, &c., P866, Engineer Office, 33, Norfolk-street, Strand, W.C. P866

Wanted, Thoroughly Experi-

ENCED DRAUGHTSMAN, preferably one with either gasworks or coke oven experience.—Address, stating age, experience, and salary required, to P875, Engineer Office, 33, Norfolk-street, Strand, W.C. P875

Wanted, Two or Three Smart

DRAUGHTSMEN, used to Railway Rolling Stock; only those thoroughly experienced need apply.—E. TURNER, Ltd., Langley Mill, Notts. 2129

Draughtsman to Take Charge of

DRAWING-OFFICE; one used to designing heavy motor vehicles preferred. Good references and experience indispensable.—Address by letter, D. J., c/o. J. W. Vickers, 5, Nicholas-lane, E.C. 2131

Draughtsman.—Wanted, Expe-

RIENCED MAN, used to Heavy Gearing and the Design of Hauling Plant; quick at calculations; give full particulars of experience, age, and salary expected; in confidence.—MATHER and PLATT, Ltd., Salford Ironworks, Manchester. 2114

An Opening Occurs for a First-

CLASS FOREMAN over a Motor Car Erecting Shop. The successful candidate must be a good organiser, active, a first-class workman, and capable of setting piecework prices from practical experience after having himself handled the job. He must also be competent to deal with from 15 to 20 cars weekly, and to superintend the number of men required for this quantity. He must be a good timekeeper (9 o'clock man), sober, and of irreproachable character.—Apply, enclosing testimonials, stating age and salary required, to HUMBER, LTD., Beeston, Notts. 2047

Wanted, Gentleman, with Neces-

SARY experience, to TAKE SECRETARYSHIP and CHARGE of BOOKS in established Engineering and Motor Building Business in South of England, with extensive garage. Must take some financial interest in same; trade increasing and profitable; will stand every investigation; principals only.—Address, 2121, Engineer Office, 33, Norfolk-street, Strand, W.C. 2121

Wanted, Junior Clerk for Engi-

NEER'S Account; good and quick writer indispensable.—Address, with age, references, salary required, 2160, Engineer Office, 33, Norfolk-street, Strand, W.C. 2160

For continuation of Small Advertisements see pages II., III., IV., *and* LXVIII.

*** *Index to Advertisements page* LXVII.

Junior Correspondence Clerk for ESTIMATING, with knowledge of Shorthand and Typewriting, used to engineers' office.—Apply by letter, stating age, experience, and salary required, to L. E., c/o Messrs. Spiers and Pond's, Ltd., Advertising Agents, 35, New Bridge-street, E.C. 2122

Wanted, an Analytical Chemist for Coke Ovens with Bye-product Plant in South Wales.—Address, stating age, experience and salary required, with copies of two testimonials, to 2120, Engineer Office, 33, Norfolk-street, Strand, W.C. 2120

Wanted, an Experienced Tyre ROLLER.—Address, 2137, Engineer Office, 33, Norfolk-street, Strand, W.C. 2137

Wanted, First-class Fitters, used to wiring up and adjusting motor cars for road test.—Apply, HUMBER, Limited, Beeston, Notts. 2128

Wanted Immediately, Linesman for erection of High-tension Transmission Lines; must be able to converse in English and German. Other applications will not be considered.—State wages and full particulars to BRUCE PEEBLES and CO., Ltd., The Chalet, Beddgelert, North Wales. 2046

Wanted in the Country, a Good WORKING FITTER, used to general repairs, with £300 capital to invest on good security, and a good return to a capable man. References must be good. This is a genuine offer.—Address, 2162, Engineer Office, 33, Norfolk-street, Strand, W.C. 2162

Wanted, Two Driver Mechanics; must be competent Fitters and Erectors, capable of rectifying any little defects found out in testing.—Apply, giving particulars of past experience, stating age and salary required, to HUMBER, Ltd., Beeston, Notts. 2119

Turner, with Good Previous experience, REQUIRED for Permanent Position in a shop doing high-class repair work in provincial town; age 35 to 40. State age, experience, and wages required. A good place for a good man.—Address, 2125, Engineer Office, 33, Norfolk-street, Strand, W.C. 2125

Wanted, by the Advertiser, who has been many years in various parts of the East as Civil and Mechanical Engineer having charge of works, a SIMILAR CLASS of APPOINTMENT where his knowledge would be of service; speaks fluent Russian, also German and French.—Address, P870, Engineer Office, 33, Norfolk-street, Strand, W.C. P870

Waterworks — Superintendent ENGINEER OPEN FOR ENGAGEMENT, high duty pumping a speciality; highest references.—Address P857, Engineer Office, 33, Norfolk-street, Strand, W.C. P857

Well-educated Mechanical En- GINEER (28), at present Works Manager, DESIRES CHANGE; excellent character and experience; energetic and good organiser.—Address, P805, Engineer Office, 33, Norfolk-street, Strand, W.C. P805

A Qualified Mechanical Engineer SEEKS EVENING ENGAGEMENT. Disengaged 5 o'clock. Designing and calculations.—Address, P826, Engineer Office, 33, Norfolk-street, Strand, W.C. P826

An Agricultural Engineer Wants SITUATION, Manager or otherwise; long experience of management all shops and offices; disciplinarian; splendid refs.—Address, P826, Engineer Office, 33, Norfolk-street, Strand, W.C. P826

An Engineer (Experienced) Seeks EMPLOYMENT (Erection or Charge of Machinery or Works, &c.), at home or abroad.—Address, P839, Engineer Office, 33, Norfolk-street, Strand, W.C. P839

Civil Engineer (23) Desires POSITION as ASSISTANT; 5 years' civil and mechanical experience surveying, referencing, parliamentary plans, &c.; university training.—Address, P828, Engineer Office, 33, Norfolk-street, Strand, W.C. P828

Engineer Desires Appointment, 20 years' experience on Important Contracts as Contractor's Engineer and Agent at home and abroad.—Address, P835, Engineer Office, 33, Norfolk-street, Strand, W.C. P835

Engineer, with Very Varied experience (railways, mines, screw-piles, bridge and roof work, machinery, &c.), DESIRES ENGAGEMENT, temporary or permanent, at home or abroad; thorough French, German, and Spanish; accustomed to Tropics; highest testimonials; would accept low salary for short engagement.—Address, P831, Engineer Office, 33, Norfolk-street, Strand, W.C. P831

Engineer, 5 Years' General Shop experience, well up in automatic, vacuum, and Westinghouse brakes, speciality—premium system, also organisation of stores department, SEEKS CHANGE.—Address, P840, Engineer Office, 33, Norfolk-street, Strand, W.C. P840

Engineer (23), Grad. Inst. Mech. Engineers, WOULD LIKE POSITION of RESPONSIBILITY in firm in or close London; used to various kinds of engine and boilerwork; 6 years' experience; or TRAVELLER.—Apply, 1, Manor-road, Forest Hill, London. P825

Engineer (28), A.M.I.M.E., De- SIRES POSITION as WORKS ENGINEER or ASSISTANT; first-class training and experience in mechanical and civil engineering; highest references.—Address, P814, Engineer Office, 33, Norfolk-street, Strand, W.C. P814

Engineer (30) Requires Engage- MENT; first-class Board of Trade certificate, 3½ years land experience, used to supervision of erection of steam and electrical plant; highest testimonials.—Address, L. W., care Davies and Co., Advertising Agents, Finch-lane, Cornhill. 2168

Engineer (32) Wants Berth as WORKS FOREMAN or ASSISTANT MANAGER. Seventeen years' experience. Works foreman last 5½ years. Good disciplinarian, and expeditious in the execution of orders. Splendid testimonials. Address, P860, Engineer Office, 33, Norfolk-street, Strand, W.C. P860

Engineer (35) Desires Position as MANAGER, ASSISTANT, or REPRESENTATIVE; mining machinery, engine and general engineering work.—GIBBINS, Swinley-lane, Wigan. P844

Superintendent Engineer Seeks ENGAGEMENT, home or abroad; experienced with compressors and mining plant.—Address, P858, Engineer Office, 33, Norfolk-street, Strand, W.C. P858

Young Engineer Seeks Situation as DRAUGHTSMAN; 7 years' practical experience; technical training; low salary to start.—D., Rosemont, Bulstrode-avenue, Heston Hounslow. P874

Young Man Seeks Position, Mechanical Engineer's Drawing-office; 5 years small shop; certificate advanced machine drawing and 3 other advanced subjects; expert boiler experience; small salary start.—Address, P861, Engineer Office, 33, Norfolk-street, Strand, W.C. P861

Draughtsman (Assistant), Age 23, SEEKS EMPLOYMENT in Drawing-office of Mechanical Engineer; 4 years' practical experience in fitting shops, &c., and 2 years' experience in drawing-offices; good references from present employer and others.—Address, direct, ARNOLD W. MEYER, 15, Elmside, Exeter. P676

Draughtsman (Experienced), shortly disengaged, DESIRES RESPONSIBLE POSITION.—Address, P837, Engineer Office, 33, Norfolk-street, Strand, W.C. P837

Leading Draughtsman Wants SITUATION; large experience in constructional ironwork and gasworks apparatus.—Particulars from P855, Engineer Office, 33, Norfolk-street, Strand, W.C. P855

Mech. Draughtsman (30) Desires BERTH; 5 years' shops, 9 years' drawing-office experience, general work.—Address, P857, Engineer Office, 33, Norfolk-street, Strand, W.C. P857

Skilled Draughtsman Disengaged (London); structural and machine design; working or finished drawings; no objection to short engagement.—Address, P873, Engineer Office, 33, Norfolk-street, Strand, W.C. P873

Tracer or Junior Draughtsman (19) DESIRES SITUATION in Mechanical Engineer's Drawing-office; 3 years' experience in D.-O.—Address, P815, Engineer Office, 33, Norfolk-street, Strand, W.C. P845

Experienced Foreman Desires RE-ENGAGEMENT; thorough knowledge of construction work, &c.; for many years employed by the Metropolitan Electric Light Co.—Address, A. DOVER, 77, Minet-avenue, Harlesden, N.W. P843

Foreman or Assistant Requires SITUATION; gauges, indicators, recorders, clocks, testers, &c.; first-class piecework system; good draughtsman.—Address, P832, Engineer Office, 33, Norfolk-street, Strand, W.C. P832

To Constructional Engineers.— FOREMAN ASSISTANT (or Responsible Position) SEEKS SITUATION; thoroughly practical in all kinds of roof, bridge, girder, building work, &c.; varied experience; well up in hour rates, &c.; previous situation 5 years; age 26; ex. refs.; home or abroad.—Address, P869, Engineer Office, 33, Norfolk-street, Strand, W.C. P869

Engineer, Electrical and Mechani- CAL, small office, commercial experience, good French, German, Spanish, and Italian, WOULD REPRESENT or ASSIST SOUND FIRM; remuneration by result.—B., 124, Chancery-lane, W.C. P833

Gentleman with Long Experi- ENCE of engineering trade in Leeds, is OPEN to ACT for good-class FIRMS DESIRING REPRESENTATION in Leeds and district. Advertiser is well-known in the trade.—Address, D 77, Robinson's Advertising Office, Leeds. P807

South Africa.—A Civil Engineer leaves London July 15th for a short visit to the chief towns; he is WILLING to ACT for OTHERS, but not as salesman, returning about October 15th.—Address, until 12th, 2151, Engineer Office, 33, Norfolk-street, Strand, W.C. 2151

South African Representative of a well-known English engineering firm will shortly be OPEN for RE-ENGAGEMENT; nine years' connection with Rand mining houses, Government railways, municipalities, &c.; practical, theoretical, and commercial experience.—Address, P487, Engineer Office, 33, Norfolk-street, Strand, W.C. P487

Accountant (30), Experienced Modern Costing, Organisation, INVITES CORRESPONDENCE.—X., Giengarriff, St. Albans-road, Moseley, Birmingham. P884

Clerk and Correspondent.— English, French, and German EXPERT TYPIST, special knowledge of Iron and Steel Trade Merchants, Consumers, and Shipbuilders, DESIRES RE-ENGAGEMENT.—H., 27, St. George's-square, Regent's Park, London. 2165

Cost Clerk, Smart, Up to Date, SEEKS PERMANENCY; thoroughly acquainted with cost office routine, card system, &c.—Address, M., 57, Rednall-terrace, Hammersmith, London. P848

Works Clerk (23) Desires Re- ENGAGEMENT, thoroughly up to date costs, stores, piecework, &c.; 6 years' experience; highest refs.—Address, P856, Engineer Office, 33, Norfolk-street, Strand, W.C. P856

Constructional Iron and Steel- WORK ERECTOR and SHEETER WANTS JOB; 20 years' experience, and first-class workman.—Apply, W. W., 129, John-street, Ettingshall, Wolverhampton. P830

Fitter (24) Seeks Situation, several classes of work, or would like improving position with small firm.—Address, P862, Engineer Office, 33, Norfolk-street, Strand, W.C. P862

Iron and Brass Moulder Seeks RE-ENGAGEMENT, references if required; highly educated, total abstainer; would accept any POSITION of TRUST.—Write X. Y. Z., 77, Corporation-street, Pointstock, Wigan. P866

Riveter and Caulker, Used to new work and repairs, SEEKS SITUATION.—Address, P827, Engineer Office, 33, Norfolk-street, Strand, W.C. P827

TO CLERKS OF WORKS, FOREMEN, &c.

The National Association for EX-SOLDIERS, 119, Victoria-street, S.W. (Telephone 367, Westminster: Telegrams, "Employous," London), SUPPLIES MEN of good character only as navvies, masons, bricklayers, porters, labourers, caretakers, carmen, carpenters, horsekeepers, night watchmen, timekeepers, &c. Characters up to date. No fees.—Apply, SECRETARY, as above. 51

An Electrical and Mechanical Engineering Firm, London works, has VACANCY for a PREMIUM PUPIL.—Address, 1892, Engineer Office, 33, Norfolk-street, Strand, W.C. 1892

Articled Pupil.—A Large Firm of Engineers in the Midlands employing upwards of one thousand hands, have a VACANCY for a PREMIUM APPRENTICE.—Address, 2036, Engineer Office, 33, Norfolk-street, Strand, W.C. 2036

Engineering Pupil.—A Firm of Engineers in the West of England have a VACANCY for a premium PUPIL.—Address, 6, Engineer Office, 33, Norfolk-street, Strand, W.C. 6

Engineering Pupil.—Firm (Government Contractors), employing 500 hands, have VACANCY; varied classes of work done, affording excellent opportunities; premium moderate.—Address, 2, Engineer Office, 33, Norfolk-street, Strand, W.C. 2

Pupil.—The Borough and Water- WORKS ENGINEER of Leamington has a VACANCY in his OFFICE for a PUPIL.—Address, Town Hall, Leamington. 2060

Engineer Desires to Invest Capi- TAL in sound ENGINEER'S BUSINESS or allied trade, with a view of securing position and share in the profits, London or district preferred.—Address, P810, Engineer Office, 33, Norfolk-street, Strand, W.C. P810

Engineer, with £3000 Capital, may SECURE VALUABLE POSITION, together with Seat on Board and ¼ Interest in PRIVATE LIMITED LIABILITY CO., with net earnings last year over 20 per cent. on capital of £12,000. This is an exceptional opportunity for young active man where no great technical knowledge is necessary to commence, but executive ability valuable. Fullest investigation courted. No agents, principals, or their solicitors.—Address, for interview, P817, Engineer Office, 33, Norfolk-street, Strand, W.C. P847

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Agents Wanted in the Principal towns and districts for a well-known SPECIALITY of some years' standing in the Millwrighting line; only men of experience and with established connection need apply.—Address, 2067, Engineer Office, 33, Norfolk-street, Strand, W.C. 2037

Belgian Engineer (Diplomé), speaking English and living in Brussels, with good business connection, UNDERTAKES INDUSTRIAL AGENCIES, and wishes to extend these. Highest references.—Address, P607, Engineer Office, 33, Norfolk-street, Strand, W.C. P607

Firm, with Splendid Old Connec- TION among Steam Users in Scotland, are OPEN to PUSH energetically GOOD SPECIALITY.—ENGINEER, care of Wm. Porteous and Co., Glasgow. P854

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Wanted by Old-established Firm of Manufacturers, a Firm of good standing in India for the SALE of ACCESSORIES for TEXTILE MACHINERY; good connections and best references required.—Address, 1784, Engineer Office, 33, Norfolk-street, Strand, W.C. 1784

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Constructional Steelwork.— DESIGNS, QUANTITIES, ESTIMATES, INSPECTION, &c. Engineers' and Architects' Drawings reported upon and Checked.—Tel. and Post address, FARNSWORTH, Strand, Derby. P268

Titley and Wall, Consulting and INSPECTING ENGINEERS and VALUERS, TUBE and ROLLING MILL EXPERTS. CURZON CHAMBERS, PARADISE-STREET, BIRMINGHAM. T101a

Appointments, at £100 to £350 a year, may be obtained by intelligent men over 21, as INSPECTORS of WEIGHTS and MEASURES, who are prepared to pass the Board of Trade Examination. Permanent positions.—Full particulars free from INSPECTOR of W. and M., Oakham, Rutland. 2169

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Wanted, First-class Horizontal BOILER, 40 or 50 horse-power, with all mountings, fittings, &c., complete, delivered London, for burning shavings, sawdust, &c.; send full particulars, with lowest price; working pressure 120 lb. to square inch.—Apply by letter, Y, care of Spiers and Pond, Ltd., Advertising Agents, 35, New Bridge-street, E.C. 2141

Wanted, First-rate 3 to 5-Ton STEAM HAMMER for making Steel Forgings.—Send full particulars to W. CECIL GUNN, 21, Laurence Pountney-lane, London, E.C. 2140

Wanted, Locomotive, 1ft. 11½in. or 2ft. gauge, new or in good condition second-hand.—Address, stating cylinder diameters, stroke, and working pressure of boiler, also lowest price for cash on rail, and where can be seen, to P859, Engineer Office, 33, Norfolk-street, Strand, W.C. P859

Wanted, Second-hand Face-plate LATHE, to swing 10ft. 6in. in pit, with boring saddle and cross ditto for turning extreme diameter; must be in good condition, treble geared, and capable of carrying 5 tons on the plate.—Address, with full particulars, 2145, Engineer Office, 33, Norfolk-street, Strand, W.C. 2145

Wanted, 6 to 8 H.P. Traction ENGINE with WINDING DRUM.—State terms for purchase, or hire 3 to 6 months, with full particulars, and where it can be seen, to BRUCE PEEBLES and CO., LTD., The Chalet, Beddgelert, North Wales. 2076

Foundry Ladle Wanted, Size 15 tons.—Send price and full particulars to SAMUEL PLATT, Ltd., Wednesbury. 2130

Second-hand Accumulator Re- QUIRED, 10in. dia., 4ft. stroke, 40 tons weight, 10 cwt. pressure.—Address, 2138, Engineer Office, 33, Norfolk-street, Strand, W.C. 2138

Steam Travelling Crane.—A Firm of Timber Merchants are OPEN to PURCHASE a SECOND-HAND CRANE, of best makers, in good condition, to lift 4 tons, at 16ft. radius, with 35ft. to 40ft. length of jib. Delivery to Cardiff.—Reply, Z. T. 266, care of Messrs. Deacon's, 154, Leadenhall-street, E.C. 2164

A Traction Engine for Sale, 6 H.P. Burrell, fitted with new Lowmoor fire-box, new tubes and crank shaft; practically equal to new. Price £175.—COBBALD BROS., Claydon, Ipswich. 1869

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Fine Lot of Mining Machinery FOR SALE, by Private Treaty, Electric Light Installations, Winding Engines and Drums, Semi-portable Boilers, Pumps, Pitch Pine Head Gears, Air-compressing and Rock-drilling Installations, Pipes, &c.; Steam and Hand Cranes, Winches, Blowing Fans, Skips, Bogies, Locomotives, and Wagons (3ft. gauge), Rails, &c.—Address, 1949, Engineer Office, 33, Norfolk-street, Strand, W.C. 1949

For Sale, Punching and Shearing MACHINES, double and single-ended. Large stock.—HY. GITTUS, Midland Ironworks, Travis-street, Manchester. A10

Boilers, Suitable for Marine and land purposes, FOR SALE cheap, built in 1896, and in excellent condition.
2 Double-ended STEEL, 12ft. 6in. and 12ft. 9in.; will re-insure for 110 lb. W.P.
2 STEEL BOILERS, 9ft. 6in. by 12ft. 6in.; will re-insure for 110 lb. W.P.
Also several LOCO. TYPE BOILERS; will re-insure for 150 lb. W.P.
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Cement Tester, Very Fine Second-hand, with Moulds complete, by Adie, FOR SALE.—Address, 1946, Engineer Office, 33, Norfolk-street, Strand, W.C. 1946

Cranes for Sale.—Three and Five TONS HAND OVERHEAD TRAVELLERS, good condition, at Caledonia Works, Kimarnock (replaced by electric cranes).—Apply, JOHN M. HENDERSON and CO., Aberdeen. 2042

Dredger and Two Hoppers (Steam) FOR SALE or HIRE, dredging to 33ft., hoppers carrying about 500 tons.—Apply, CONSTANT, 11, Billiter-square, London, E.C. 1959

Electric Light Installation, Com- PLETE with Dynamo and Oil Engine, suitable for tunnel work, &c., FOR SALE.—Address, 1948, Engineer Office, 33 Norfolk-street, Strand, W.C. 1948

For Delivery from Stock:—
One new PLANING MACHINE, to plane 6ft. long, 30in. wide, 30in. high, with one tool-box on cross-slide.
One Second-hand PLANING MACHINE (by Woodward and Powell, Worcester, Massachusetts, U.S.A.), to plane 6ft. long, 24in. wide, 24in. high, with one tool-box on cross-slide. Nearly new, only worked three months. In excellent condition. Can be seen running.
One new 6½in. centre HAND LATHE.
One new 14½in. centre SLIDING, SURFACING, and SCREW-CUTTING LATHE, on 20ft. box-end gap bed.
One new 36in. Double-geared PILLAR DRILL, with four wheels by cone machine cut from solid.
One 30in. Double-geared PILLAR DRILL, with four wheels by cone machine cut from solid.
One 16in. BENCH DRILL.

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One to plane 8ft. long, 30in. wide, 30in. high, with 2 tool-boxes on cross-slide. Delivery in 3 to 4 weeks.
One to plane 10ft. long, 3½ft. wide, 3ft. high, with 3 tool-boxes on cross-slide. Delivery in 3 to 4 weeks.
One to plane 16ft. long, 4ft. wide, 3½ft. high, with 3 tool-boxes on cross-slide. Delivery in 3 to 4 weeks.

C. REDMAN AND SONS, HALIFAX. Q433a

For Hire, Pumps and Well- BORING TOOLS for Contractors, Deep Wells, &c., 2in. to 24in. diam.—R. RICHARDS and CO., Upper Ground-street, London, S.E. Telephone No. 976 Hop. 822

For Sale:—
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Two do. do. by Armstrong, Whitworth.
Four 11in. Centre Triple-geared SCREW-CUTTING LATHES, Southgate Engineering Co.
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Nearly New PARTING-OFF LATHE, to take up to 10in. dia.
Double-ended TURRET LATHE, to take 5½in. through spindle, by Whitworth and Co.
PLANING MACHINE, to plane 20ft. × 5ft. 9in. × 3ft. 9in.
PLATE-EDGE PLANING MACHINE, to plane 17ft. 6in.
Muir's Patent PLANING MACHINE.
Double-ended Cross-cut SHEARING MACHINE, engine driven, Buckton and Co.
Catalogue of over 2000 machinery lots free on application.
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Inspection invited.
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For Sale:—
14in. by 20in. 6-wheels coupled SIDE TANK LOCOMOTIVE, being re-built, new boiler, &c.; also 13in. by 18in. 6-wheels coupled Manning Wardle SADDLE TANK LOCOMOTIVE, now being re-built; both equal to new.
THE AVONSIDE ENGINE COMPANY, BRISTOL. Y149

For Sale, a 2ft. 3in. Gauge, 20 H.P. LOCO. by Orenstein and Koppel, at Sewage Works, Aylesbury; a Half-yard Taylor's Patent CONCRETE MIXER, at Wimbledon Goods Station; may be viewed.—Offers to HORNE and CO., 25, Gresham-street, E.C., by July 5th. 2077

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For Sale, Engines:—
1 HORIZONTAL, 30 N.H.P., by Marshalls.
1 VERTICAL, cylinder 22in. diam., 26in. stroke, with heavy spur fly-wheel.
Cheap to avoid second removal.
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For Sale, Excellent Coupled COMPOUND HORIZONTAL ENGINE by Marshalls, Gainsboro', 19½in. h.-p. cylinder, 31½in. l.-p. cylinder, 30in. stroke, with automatic expansion gear, rope fly-wheel.—R. H. LONGBOTHAM and CO., Ltd., Ings Foundry, Wakefield. 1000

For Sale, Mushet Steel, 8¼ Cwt 14in. by 3in., 8¼ cwt. 3in. square, 9 cwt. 3in. square.—Address, 400, Engineer Office, 33, Norfolk-street, Strand, W.C. 400

For Sale, New Steel Lancashire BOILERS, ready for immediate delivery:—
Six 30ft. × 8ft. dia., for 100 lb. working pressure.
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Six 30ft. × 8ft. 6in. dia., for 120 lb. ditto.
Other sizes in progress.
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SEMI-PORTABLE ENGINES, 12 to 60 N.H.P.
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PLOUGHING ENGINES and Implements.
CENTRIFUGAL PUMPS.
SAW BENCHES and SAWS.
Immediate delivery from works for breakdowns, &c.
HENRY LEWIS AND SONS, ENGINEERS, READING. Y713
Telegrams: "Lewis, Reading." Full list free.

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One SET do. do. 10in. and 20in. by 14in. stroke.
Also BOILERS suitable, passed Lloyd's. Can offer above reasonable.
Apply, CRABTREE and CO., Ld., Great Yarmouth. 2158

For Sale, Punching and Shearing MACHINES, 14in. through 1¼in., and 14in. through 1¼in. Delivery from stock.
HUGH SMITH and COY., Ltd., Possil Engine Works, Glasgow. 433

INDEX TO ADVERTISEMENTS.

Advertisements not appearing this week, but included in the "Subject Matter Index," will be found by reference to the preceding or following issues, with the exception of those appearing monthly.

	PAGE
Abbot, John, and Co., Ltd	61
Abbott and Co., Ld	25
Acme Lathe & Products Co	62
Ahlers, Ad.	45
Aird, J.	3
Akrill, C., and Co., Ld	60
Allen, Edgar, and Co	35
Allen, J. G., and Co	35
Allen, W. H., and Co., Ld	31
Alley and Maclellan	25-15
Armstrong, Stevens and Son	67
Arrol, Sir W., and Co., Ld	45
Asbestos Co., Ld., United	31
Ash, J., and Son	68
Ashton, Frost and Co., Ld	48
Ashton Valve Co	48
Ashworth, E.	4
Asquith, W., Ld	4
Atkinson, Robt. (Lond.), Ld.	68
Auld, D., and Sons	61
Avonside Engine Co	2
Babcock and Wilcox, Ld	7
Bagshawe and Co	49
Bagshaw, J., and Sons	3
Bagshaw, W. G., Ld.	3
Bailey, W. H., & Co	20
Baker, J. & Co (Rotherham)	45
Baker, J., and Sons, Ld	6
Baker's Pat. Appliances Co	65
Balcke and Co	45
Barns, W., and Sons	22
Barrowfield Ironworks, Ld	48
Barry, Henry and Co	5
Batchelor, R. D.	37
Baxter, W. H., Ld	68
Bayliss, Jones & Bayliss, Ld	11
Beardmore, W., and Co	55
Bateson and Son	46
Beck, R. and J., Ld	6
Bedford Engineering Co	50
Bellhs and Morcom, Ld	65
Bennroe and Sons, Ld	22
Bennis, E., and Co., Ld	22
Best Belting Co	6
Blackstone and Co., Ld	51
Blake & Knowles' Pump Wks	21
Blake, J., Ld	66
Boby, R.	68
Bodley Bros. and Co.	48
Booth, Jos., and Brothers	44
Borsig, A.	43
Bourne Drying & Ventlg Co	4
Boyle, Robt., and Son	35
Braby, F., and Co	35
Bradley and Craven, Ld	57
Breuer, H., and Co	57
Britannia Co	65
Brit. Mannesmann Tube Co	37
British Uralite Co., Ld.	69
Broadbent, T., and Sons	60
Brown Bayley's Steel Works	65
Brown, D., and Sons	58
Bruce Peebles and Co., Ld	30
Buck and Hickman, Ld	62
Buckton, J., and Co., Ld	68
Buffolino Noiseless Gear Co	46
Bull's Metal & Melloid Co., Ld	35
Burnham, Williams and Co	57
Butterley Company, Ld	4
Cail Engineering Co	21
Caird and Rayner	55
Cameron, J.	27
Cammell Laird and Co., Ld	27
Campbell Gas Engine Co	35
Campbells and Hunter	6
Carbrook Steel Works	41
Carr and Nicholls, Ld.	49
Carrick and Marshall	21
Carter's Steam Wagon Co	28
Chatwin, T.	58
Clarkson a	3
Clay Cross Co	4
Clayton, Son and Co., Ld	56
Cleveland Bridge & Eng. Co	59
Clifton and Waddell	55
Clyde Structural Iron Co. Ld	65
Cochran & Co., Annan, Ld	65
Cole, Marchent and Morley	5
Colen, H.	68
Coltman, H., and Sons	16-49
Coltman, W. W.	59
Combe Barbour, Ld	3
Consolidated Eng. Co., Ld	32
Consolidated Pa'ie Tool Co.	18
Conveyor and Elevator Co	68
Cook and Hammond	68
Cooper, E., and Co., Ld	5
Cowans, Sheldon and Co., Ld	4
Craig, A. F., and Co.	57
Craven Brothers, Ld	53
Cravens Limited	4
Crompton and Co., Ld	21
Crossley Brothers, Ld	21
Crowther, H., and Sons, Ld	35
Cutten Brothers	4
Dale Wilg & Ventlg Co	4
Daniell, S. A., Ld	62
Daniels, T. H. and J., Ld	7
Darlington Construction Co	61
Davey, Paxman and Co., Ld	17
Davis, J., and Son, Ld	61
Davies and Metcalfe, Ld	55
Davis and Primrose	49
Davis Engineering Co	3
De Bergue and Co	49
Delta Metal Co	35
Dick, Kerr and Co	26
Dixon Crucible Co	19
Douglas, Lawson and Co	61
Doulton and Co	51
Drum Engineering Co	8
Drysdale and Co	65
Duhkerley, C. C., and Co	5
Easton and Anderson	16
Easton and Bessemer, Ld	51
East Ferry-road Engin'ng Co	43
Edmeston, A., and Sons	58
Edward's Air Pump Synd	68
Electric Welding Co., Ld	50
Electromotor & Dynamo Co	56
Elliot, Jas., and Co	60
Evans, J., and Sons	60
Fairbanks Co	33
Farmer, L., and Sons	68
Farnley Iron Co	3
Fawcett, Preston & Co., Ld.	65
Fielding and Platt, Ld	50
Findlay, Alex., and Co.	6
Firth, T., and Sons, Ld.	41
Fleming and Ferguson	7
Fleming, Birkby & Goodall	40
Fodens Limited	51
Fuller, Horsey, Sons & Cassell	68
Gandy Belt Manufturing Co	48
Gilbe t Little Co., Ld	4
Gilkes, G., and Co	59
Gimson and Co., Ld	62-68
Glasgow Railway Eng. Co.	4
Globe Pneumatic Eng. Co.	12
Grafton and Co	19
Grantham Crank and Iron Co	8
Grice, Grice and Son	23
Grice, W., and Sons	11
Griffin, C., and Co	68
Griffith, W., and Sons	4
Guest, Keen & Nettlefolds	35
Gunther, W., and Sons	51
Haigh, W. B., and Co., Ld.	45
Haley, E. and W. H.	48
Hall, J. and E., and Co.	35
Hall, J. P., and Co., Oldham	55
Hall, J. S., and Co., Ld	45
Hamblet, Joseph	3
Hambletts Ld	35
Hanbury, J., and Sons	61
Handyside and Co., Ld.	16
Hardy and Padmore, Ld	28
Hardy Patent Pick Co	3
Harpers Limited	66
Harris and Mills	35
Harrison and Camm, Ld	4
Harrison Engine Co., Ld	62
Hartnell, W.	65
Harzer, C., and Co	51
Haslam Fdry & Eng'g Co. Ld	18
Hawthorn, Leslie & Co.	65-68
Hayes, Edward	48
Hayward-Ty or and Co	35
Head, Wrightson & Co., Ld	47
Heenan and Froude	21
Henderson, J. M., and Co.	41
Hendry, James	51
Hepburn Gale and Ross, Ld	22
Herbert, A., Ld	4-10-59
Hetherington, J., & Sons, Ld	59
Higginbottom and Mannock	51
Higgins and Co	50
Holt and Willetts	25
Hooker, P.	68
Horsfall Destructor Co., Ld	8
Hornsby and Sons, Ld.	3-10
Horseley Co., Ld	6
Howard Engineering Co	38
Howell and Co., Sheffield	46
Howes, S.	47
Hudswn Economiser Co., Ld	64
Hudson, R.	49
Hudswell, Clarke and Co	11
Hughes and Lancaster	53
Hulburd Engineering Co	8
Hulse and Co., Ld.	35
Hunslet Engine Co.	9
Hunt, Sons and Bright	3
Ince Forge	68
India-rubber Mfg. Co., Ld	66
Inca Foundry and Eng. Co.	68
Isler, C., and Co	66
Jackman, J. W., and Co	59
Jonsen and Son	3
Jessop and Appleby Bros	39
Johnson and Phillips	3-8
Jones & Lamson Mach'e Co.	6
Kalis, W. Zoon and Co.	15
Kay, James C., and Co.	47
Kaye, J., and Sons	58
Keayon, W., and Sons	6
Kerr, Stuart and Co	4-15
Kirk, Price and Co.	68
Klinger, R., and Co	19
Krupp Grusonwerk, F.	11
Laidlaw, R., and Son	55
Lancashire Steam Motor Co	8
Lancaster and Tonge, Ld	61
Larmuth, T., and Co	12
Lassen and Hjort	4
Laurence, Scott and Co., Ld	14
Ledward and Beckett	35
Leeds Forge Co., Ld	31
Leroy, F., and Co	61
Lees, T. and R.	37
Lecto's	62
Lewis and Tylor, Ld	6
Liverpool Eng'g & Condr Co	49
Llewellin's Machine Co	35
Lobnitz and Co., Ld	65
Lockwood, C., and Son	63
Lockwood and Carlisle	57
Loco. & Mach. Co., Montreal	57
Lowca Engineering Co., Ld	68
Luke and Spencer, Ld.	54
Lysaght, John, Ld.	17
Mackies, Ld	47
Maclellan, P. and W.	4
Magnolia Metal Co., Ld	11
Mallinson and Co	23
Mann's Patent Wagon Co	47
Mansfield, E., and Sons	8
Marsden, H. R.	31
Marshall, Fleming & Jack	49
Mason Bros.	47
Matthews and Yates, Ld	50
Measures Brothers, Ld.	43
Melhuish, Sons and Co., Ld	37
Mellowes and Co	18
Mercer, E.	16
Mirrlees Watson Co., Ld	62
Mitchell's Emery Wheel Co	66
M'Neil, C., Jun.	22
Moncrieff, J.	37
Moore and Clark	55
Moseley, D., and Sons, Ld.	34
Motherwell Bridge Co., Ld.	6
Muir, W., and Co	22
Mumford, A. G.	3-15
Musgrave and Co., Ld.	37
Nasmyth, Wilson and Co., Ld	28
National Gas Engine Co., Ld	53
New Conveyor Co., Ld.	15
New Explosives Co., Ld	61
Newton, Chambers & Co., Ld	53
Noble and Lund	8
Normandy's Fresh Water Co	61
North British Loco. Co., Ld	42
North-East'n Marine Eng. Co	47
Oakey, J., and Sons	57
Oldham Boiler Works Co	4
Ord and Maddis n, Ld.	47
Owen, J., and Sons, Ld.	6
Owens, S., and Co	61
Parsons, C. A., and Co	61
Parkins n, J., and S.n	22
Pearn, F., and Co	25
Peckett and Sons	50
Peebles Steam Car Co., Ld.	65
Pelé H., and Co	9
Petter, J. H., and Sons, Ld	63
Pfeil and Co	51
Phillips' Commutator Grinder	57
Phillips, J., and Co	6
Pierson, L. and O. G.	5
Piggott, T., & Co., Birm'ham	44
Pilkington Bros., Ld	44
Platt, Samuel	22
Plenty and Son	42
Pollock, Macnab & Highgate	63
Pollock, Whyte and Waddel	57
Pott, Cassels and Williamson	4
Power-Gas Corporation, Ld	35
Premier Gas Engine Co., Ld	60
Price, J	3
Priddle and Heppell	65
Pulsometer Engin'ng Co	34
Purden, J., and Sons	16
Ransome, A., and Co., Ld.	41
Reader, E., and Sons, Ld	51
Recorders Li	6
Redfern, G. F., and Co.	35
Redman, C., and Sons	2
Reid, W., and Co	33
Reinecker, J. E.	51
Reveirs, G.	22
Rh des Electrical Mfg. Co.	35
Rhodes, J., and Sons, Ld	28
Richards, R., and Co	2
Rimington Bros	4
Robey and Co	32
Robinson, T., and Son, Ld	40
Rodger, A., and Co	37
Roger, R., and Co., Ld	37
Roots, J. D., and Lean	35
Rose, Downs and Thompson	15
Ross and Duncan	35
Rowell, D., and Co	6
Rowland, B. R., and Co	28
Royal Dutch Forge Co	37
Royles Limited	46
Rushworth and Livsey	48
Russell, George, and Co	36
Russell, James, and Sons, Ld	26
Russell, John, and Co., Ld.	63
Ruston, Proct r and Co	14
Ryder, T., and Son	49
Sagar, J., and Co., Ld	68
Samuelson and Co., Ld	52
Sanit ry Publishing Co., Ld	68
Schram, Harker and Co	68
Schwartzkopff Syndicate	5
Scott and Hodgson, Ld	47
Scott and Mountain, E., Ld	55
Shanks, T., and Co.	35
Siebe, Gorman and Co	43
Smith, G. F., Ld	5
Smulders, A. F.	6
Spencer, C., and Sons	3
Spencer, W. H., and Co	57
Stableford and Co	6
Standard Oil Engine Co	37
Steel, Peech and Tozer	42
Steel Company of Scotland	59
Stephenson, R., and Co., Ld	4
Sterne, L., and Co.	34
Stern-Sonneborn Oil Co	7
Stewarts and Lloyds, Ld	36
Stothert and Pitt	61
Summerscales, W., and Sons	46
Summerson, T., and Sons, Ld	35
Swan Hunter and Co., Ld	35
Talk o'th Hill Colliery, Ld	6
Tandem Smelting Synd., Ld	58
Tangyes Limited	9
Tannett Walker and Co., Ld	42
Taylor and Challen, Ld	54
Taylor and Hubbard	28
Tees Side Bridge & Eng Wks	12
Temperley Transporter Co.	61
Thermit, Ld	46
Thornycroft, J. I., and Co	46
Thorp, Joseph, and Co	68
Tilghman's Sand Blast Co., Ld	68
Timbrell & Wright Eng'g Co	56
Tinker, Shenton and Co	43
Tomey, J., and Sons, Ld	39
Towniey, George	56
Trier Brothers	49
Tullis, D. and J., Ld	56
Turnbull, A., and Co., Ld.	48
Turner, E. R. and F.	59
Turner, G. R., Ld	4
United Asbestos Co., Ld	31
U.K. Metallic Packing Synd.	8
Universal Tube Co., Ld	58
Urquhart, Lindsay & Co., Ld	53
Vacher, H. P.	63
Vaughan and Son, London	35
Vauxhall Ironworks Co	68
Vickers, Sons & Maxim,	18
Vulcan Boiler Insurance Co	50
Waddle Pat. Fan & Eng. Co	6
Wadkin and Co	19
Walles, G., and Co	68
Wakefield, C. C., and Co	4
Walker, J., and Co.	32
Wallach Brothers	16
Ward, H. W.	49
Ward. T. W., Ld	2
Warner, R., and Co	62
Waygood, R., and Co., Ld	35
Webb and Son	16
Webster and Bennett	62
Weir, G. and J.	66
Weldless Steel Tube Co	3
Wellman-Seaver-Morgan Co	44
Wells, A. C., and Co.	23
Westinghouse Brake Co	21
Wheeler Condser & Eng. Co	26
Wicksteed, C., and Co	57
Widdowson, J. H.	43
Wigglesworth, F., & Co., Ld	32
Wilkinson, G., and Son	16
Williams, S., and Sons	49
Willans and Robinson	4
Willcox, W. H., and Co., Ld	7
Wilson, Alex	3
Wilson, J. H., and Co., Ld.	21
Wimshurst, Holliet & Co., Ld	4
Winter, F.	6
Wise-Howorth, F.	68
Witty and Wyatt, Ld	4
Wood and Newland	68
Wootton Bros	5
Worthington Pump Co	24
Wright, Joseph, and Co	15
Wright, F., and Sons	68
Yarrow and Co.	68
Youngs	46

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SALE OF OBSOLETE WAR VESSELS, HULKS, AND OTHER CRAFT.

BY ORDER OF THE LORDS COMMISSIONERS OF THE ADMIRALTY.

Messrs.

Fuller, Horsey, Sons & Cassell

are instructed to OFFER for SALE by AUCTION, at H.M. Dockyard, Portsmouth on TUESDAY, July 11th, at eleven o'clock precisely, the following

OBSOLETE WAR VESSELS AND OTHER CRAFT,

of which Lots 1, 2, 3, 5, 9, 10, 14 to 18, and 20, are lying at or off Portsmouth Dockyard, Lots 4, 6, 7, 8, 11, 12, 13, 19, 22, and 23, off Devonport Dockyard, where they may be viewed by orders to be obtained of the Admiral-Superintendents at the respective dockyards, and Lot 21 is lying at Cardiff.

LOT 1.—The First-class ARMOURED CRUISER HECTOR, 6710 tons displacement, 390ft. long, 56ft. 3in. beam, iron built, and plated with armour 4½in. in thickness, weighing about 913 tons, and equipped with three masts and metal propeller.

LOT 2.—The First-class ARMOURED CRUISER ORLANDO, 5600 tons displacement, 300ft. long, 56ft. beam, steel built, and plated with armour, 10in. to 16in. in thickness, weighing about 460 tons, equipped with two sets of horizontal triple-expansion engines of 8500 I.H.P., metal condensers and brass tubes, four double-ended multitubular steel boilers, auxiliary engines and pumps, gun-metal propellers, &c.

LOT 4.—The Third-class CRUISER MAGICIENNE, 2950 tons displacement 265ft. 2in. long, 42ft. 2in. beam, steel built and copper sheathed, two sets horizontal triple-expansion engines of 5500 I.H.P., metal condensers and tubes, four double-ended tubular steel boilers, auxiliary engines and pumps, gun-metal propellers, &c.

LOT 5.—The Third-class CRUISER FEARLESS, 1580 tons displacement, 220ft. long, 35ft. beam, two sets horizontal compound engines of 1750 I.H.P., four boilers, auxiliary engines and pumps and gun-metal propellers

LOTS 6, 7, and 8.—The Third-class CRUISERS BLANCHE, BLONDE, and BARROSA, of somewhat similar description.

LOT 9.—The Twin-screw SLOOP BEAGLE, 1170 tons displacement, 190ft. long, 30ft. 4in. beam, steel built, copper sheathed, two sets triple-expansion engines of 1400 I.H.P., two steel boilers, auxiliary engines, &c.

LOT 10.—The First-class TORPEDO GUNBOAT JASEUR, 810 tons displacement, 230ft. long, 27ft. beam, steel built, two sets of triple-expansion engines of 2500 I.H.P., four loco-type boilers, auxiliary engines, &c.

LOTS 11 and 12.—The First-class TORPEDO GUNBOATS BOOMERANG and KARRA-KATTA, 735 tons displacement, of nearly similar description.

LOT. 13.—The First-class TORPEDO GUNBOAT GRASSHOPPER, 525 tons displacement, 240ft. long, 23ft. beam, two sets of triple-expansion engines, 1600 I.H.P., four loco-type boilers, auxiliary engines, &c.

LOT 14.—The TANK VESSEL PELTER, 370 tons, 115ft. long, 22ft. beam, iron built, jet condensing engines, boiler, gun-metal propeller, &c.

LOT 15.—The FANCY, late SCREW GUNBOAT, 281 tons displacement, 111ft. long, 22ft. 9in. beam, timber built, copper fastened and copper sheathed.

LOT 16.—The Third-class GUNBOAT PINCHER, 255 tons displacement, 85ft. long, 26ft. 1in beam, iron built, two sets horizontal trunk engines, boiler, &c.

LOT 17.—The PADDLE YACHT ENCHANTRESS, 1000 tons displacement, 220ft. long, 28ft. 2in. beam, timber built, copper fastened and copper sheathed, set of oscillating engines of 1100 I.H.P., four iron boilers, &c.

LOT 18.—The Old HULK PITT, 4140 tons displacement, 229ft. long, 51ft. 6in. beam, timber built, copper fastened and copper sheathed.

LOT 19.—The old HULK LION, 3042 tons displacement, 190ft. long, 57ft beam, timber built, metal fastened and copper sheathed, and 90 tons pig iron ballast.

LOT 20.—The old HULK MYRTLE, 2761 tons displacement, 184ft. 9in. long, 48ft. 6in. beam, timber built, metal fastened and copper sheathed, and 150 tons pig iron ballast.

LOT 21.—The old HULK HAMADRYAD, 1540 tons displacement, 151ft. long, 39ft. 9in. beam, timber built, metal fastened and copper sheathed, and 100 tons iron ballast.

LOT 22.—The SAILING BRIG NAUTILUS, 501 tons displacement, 105ft. long, 33ft. 6in. beam, timber built, metal fastened and copper sheathed, and 60 tons pig iron ballast.

LOT 23.—The SAILING BRIG LIBERTY, 447 tons displacement, 100ft. 6in long, 32ft. 4in. beam, with 35 tons pig iron ballast.

LOTS 2, 4, 6, 7, 8, 10, 11, 12, and 13 will be sold subject to their being broken up within the United Kingdom; Lots 1, 3, 5, and 9 must be broken up, but not necessarily within the United Kingdom; and the remaining lots will be sold without any obligation as to breaking up.

Full descriptive particulars, with conditions of sale, may be had on payment of 1s. each, or 10s. for the series (returnable to purchasers), of Messrs. FULLER, HORSEY, SONS and CASSELL, 11, Billiter-square, E.C. 2125

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BY ORDER OF THE LORDS COMMISSIONERS OF THE ADMIRALTY.

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